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TURNBERRY

1918

149

NOTES TO BE WRITTEN BY OFFICERS
& N.C.Os UNDER INSTRUCTION.

GUNS:-

Page 9 - 18 to the words "The upper lever of the feed-block" on the latter page.
Page 20 down to "The live round in the feed-block".
Pages 22, 26 and 28 down to "Thus giving a No 3 Stoppage".

CARE AND CLEANING:-

Start at "General Points" on Page 28 and finish at the words "Armament Officer" on page 31.

FILLING OF BELTS:- Pages 33 & 34.

RING SIGHTS:- Pages 37 - 64.

HARMONIZATION OF SIGHTS:-

Pages 66, 67, & 70 and details of machine flown.

C.C. GEAR.

Page 86.
Fitting of Generator on page 88.
Pages 91. 92. 93. 94. &
Fault Table.

Kauper Gear Complete.
(for all Scout Pilots)

F. G. Clarkson 2nd Lt R.A.F.

P. A.

High Stoat

Brackley.

Northants.

GU

CA

FI

RI

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C.

NOTES

ON

GUNS, GEARS AND SIGHTS

TURNBERRY

1918

AYR: OBSERVER OFFICE, UNION ARCADE

INDEX.

	PAGES
Commandant's Address, ...	5 – 8
Notes on the Vickers Gun—	
Points before, during and after Flight, ...	9—10
Repairs and Adjustments, ...	10—19
Stoppages,...	20—28
Care and Cleaning,...	28—31
Belt Filling, ...	32—35
Ring Sight, ...	37—62
Aldis Sight, ...	62—65
Harmonization of Sights, ...	66—82
Loading Handles, ...	84—85
C.C. Gear, ...	86—97
Kauper Gear, ...	98—103

COMMANDANT'S ADDRESS.

The Importance of Gunnery Training.

The Offensive Spirit.

The importance of encouraging and infusing the offensive spirit into all Pilots cannot be over estimated. Pilots in every type of Squadron must be made to realise that, whatever their task, they will be required to fight—and the importance of taking the offensive at all times must be continually brought home to them. For Scout Squadrons a fighting spirit must be instilled into Pilots from the start. They must be taught that for fighting they exist, that their whole duty on Active Service begins and ends with fighting; that whereas in the case of other types—reconnaisance, bombing or artillery machines,—fighting may be incidental to their main task, in the case of Scouts it is their raison d'être. Their first and all important duty is to seek out and destroy the enemy wherever he may be found.

To possess this essential "Offensive Spirit" you must first have absolute confidence in:—

1. Your ability to Fly.
2. Your Machine.
3. Your Engine.
4. Your Gunnery.

That confidence cannot possibly be obtained unless you take a personal interest in, and thoroughly understand, your machine, engine, gears, and guns.

Before leaving the ground overseas you will satisfy yourself that your machine and engine are in order. You must realise that it is equally important to satisfy yourself that your gun is also in proper order.

Examples of Experts.

It is interesting to note that all Pilots who have done well, such as Captains Ball, Bishop, Rhys-Davids, Luchford, Fullard, and many others, all took a personal interest in their guns, gears, and sights, and although they did not in all cases actually clean their guns, or fill their belts, they satisfied themselves that everything was done correctly, which, undoubtedly, gave them absolute confidence. The following examples will be of interest in this connection :—

(a) When in 60 Squadron Capt. Ball was at first laughed at, because he seemed to always have his machine at the butts in flying position. He was satisfying himself that his sights were correctly aligned, and it was soon admitted that there was method in his madness.

(b) When 56 Squadron went overseas for the first time, Capt. Ball insisted on all the Pilots in his flight looking after their own guns and gears in every particular.

(c) Capt Bishop stated as follows, when asked for his opinion :—

"A Pilot or Observer not knowing thoroughly his gun, gear, and engine, had to sit on the ground and work night and day until he did.

New Pilots should take this seriously to heart, because it at once exposes in them a lack of keenness in that they have not paid any attention whilst being taught at home, and when they get overseas they are soon very sorry for it.

They must realise that they have got to know it thoroughly, and not be satisfied with just knowing something about it."

(d) Capt. Fullard, who is said to have over 40 Huns to his credit, told me that he always looked after his own gun, and boasted that he had fired over 5,000 rounds on his Lewis gun without a stoppage.

To keep his hand in he often stripped the gun on his lap while in the air. He said he was quite confident that his gun would always fire when he wanted it.

(e) Capt. Guynemeyer, when visiting one of the British Squadrons, pointed out that he attached so much importance to gunnery that the guns, gears and sights on his machine were his private property, and that he looked after them himself in every detail.

56 Squadron.

(f) Extract of Report from Capt. Maxwell and Lt. Barlow as to gunnery arrangements in 56 Squadron :—

"Each flying officer filled and tested his own Vickers and Lewis ammunition. Flight Commanders had their ammunition filled and tested by the man in charge of that particular gun.

Capt. Ball was very particular about his ammunition and filled it himself or got one of his flying officers to do it for him.

New pilots on arriving in the Squadron were sent up as often as possible to fire their guns in the air, to thoroughly acquaint the pilot with his guns and machine. A new pilot always did at least five hours flying before going on patrol.

When a patrol returned all stoppages were reported, and the guns in question tested on the range for cause of trouble. In this way it soon became a rarity for people to complain of stoppages The pilot himself was always present when the gun was being tested, and fired it himself.

Patrols on reaching the lines always tested their guns towards Hunland. Pilots were held absolutely responsible for stoppages on their guns, and it was very seldom that anybody returned from patrol with gun trouble.

Everybody in the Squadron took a personal interest in their guns, and if their guns were not going well they experimented on the range with Spring Tensions and File, etc, until they did go well.

We were very particular about testing ammunition, and all discarded ammunition was fired on the range for stoppage practice.

After a little trouble had been taken with the guns to start with, it was extraordinary how few stoppages occurred, in fact several people fired over 5,000 rounds without a single stoppage which could not be rectified at once, *i.e.*, Misfire, etc."

This personal interest was taken by the officers in 56 Squadron notwithstanding the fact that the Armament Staff consisted of an Armament Officer, a Sergeant in charge of the guns, 1 man at Headquarters in charge of repairs to C. C. Gears, and 3 men in each flight.

56 Squadron, as you are aware, possess perhaps the best record in the Royal Air Force, and it is doubtless largely due to the fact that the importance of taking a personal interest in everything to do with their machines was fully realised by all.

Course at Turnberry.

While at Turnberry it is your last opportunity of receiving instruction in Gunnery. From the moment you leave you will have to depend upon the knowledge you have acquired. It is, therefore, very important that you take every opportunity while here to collect all information possible.

You have been given complete notes on the principal subjects. Copy them into your note book. The more complete and comprehensive you make your book now, the more you will appreciate it later, when you may wish to refer to it.

Some of you appear to think that you can keep all this information in your head, but you cannot without constant practice.

Unless you know your gunnery thoroughly you are not in a position to tell whether the armourers in your Squadron are doing what is right and necessary. In other words, you are not in a position to take the personal interest that is so essential to success and safety.

After Leaving Turnberry.

Do not leave this School with the idea that, having passed the Course, you are a qualified gunner, ready to tackle any Hun. You are far from it.

Constant practice is required, and it is your duty to take every opportunity to practise, both on the ground and in the air.

You must become absolutely mechanical with your stoppages, which can only be done by constant practice. Test your gears and the alignment of your sights at regular intervals.

Two-Seater Pilots.

The closest co-operation between Pilot and Observer is most essential. They must possess absolute confidence in each other.

When an Observer is alloted to you (you will probably keep the same one throughout), satisfy yourself that he knows his gunnery, as your safety very largely depends upon him when you are attacked from behind. You must also be in a position to convince him that you know your gunnery, otherwise you cannot expect him to have confidence in you.

Overseas.

Those of you who go to France as re-inforcement Pilots may find that, after having passed certain Brigade tests, you are given little encouragement to keep up your gunnery.

Do not let that prevent you from following the example of the expert Pilots, *i.e.*, taking the personal interest, which has been proved to be so essential to success.

Finally, you must all realise that your own safety, and the safety of your Observer if you are a 2-seater Pilot, depends entirely on your individual efforts.

R. BELL-IRVING, L.-Col.,
Commandant.

Notes on the Vickers Gun.

POINTS BEFORE, DURING, AND AFTER FLIGHT.

Points Before Flight.

1.—See that the barrel is perfectly clean but has a slight film of oil.

2.—See that the frictional parts are lightly oiled with P 924 in winter and with a mixture of oil, lubricating G.S. and P 924, in summer.

3.—Weigh the recoiling portions. The method to be adopted in carrying this out will be given under "Repairs and Adjustments." For aerial purposes the weight of the recoiling portions should not exceed 2 lbs.

4.—Weigh the fusee spring. The method to be adopted in carrying this out will also be given under "Repairs and Adjustments." All Vickers guns for R.A.F. use are now carefully tested by the Gun Testing Section at Uxbridge. From these tests the most efficient fusee spring weight is determined and is duly entered in the History Sheet accompanying the gun. This weight should invariably be adhered to. For aerial purposes the weight of the fusee spring should be:—

(a) With the Mk. I. muzzle cup, from 9 to 11 lbs.

(b) With the Mk. II. muzzle cup and ·05 heavy recoil washer, from 10 to 12 lbs.

The weight of the fusee spring should never exceed 12 lbs.

5.—Inspect the muzzle attachment. The steel disc and muzzle cup should be clean and bright. With the Mk. II. muzzle cup, the ·05 washer must be in position, the steel disc and muzzle cup clean and bright, and the latter screwed on tightly.

6.—See that the gun is accurately and securely fixed on its mounting.

7.—See that the loading handle has been correctly fitted and does not in any way interfere with the movement of the crank handle.

8.—See that the Foroto spring and rear cover catch are correctly fitted.

9.—See that the Foroto jam clearer and spare lock are in the machine.

10.—Examine ammunition chutes and box to see that they are correctly fitted.

11.—See that the link belts are correctly filled and placed correctly in the ammunition box.

12.—See that the first round in the belt is engaged in front of the bottom pawls.

13.—Test the fitting and timing of the gear.

14.—Carefully check the harmonization of the sights. The range at which sights are harmonized varies in different squadrons. This harmonization must always be checked by firing short bursts on the range.

It will be noted that the "Points Before Flight" are divided into four sub-heads, viz. :—

Gun, Ammunition, Gear, Sights.

The points under sub-head No. 1 are nine in number; those under sub-head No. 2, 3 in number; and one under each of sub-heads 3 and 4.

Points During Flight.

1.—Fire occasional short bursts to prevent the working parts from becoming clogged with congealed oil

2.—Unload the gun before landing.

Points After Flight

(Under the supervision of the Armament Officer).

1.—Unload.

2.—If possible remove the recoiling portions. Take them to the Armoury and see that they are thoroughly cleaned and re-oiled.

3.—Clean the non-recoiling portions, using petrol or spirits of turpentine to remove clogged oil. Thoroughly dry and re-oil.

4.—Have all unused ammunition re-tested. This is important.

5.—Examine chutes to see that they are not damaged or displaced.

6.—Examine sights to see that they are not damaged.

7.—Any stoppage or apparent defect in the working of the gun must be immediately reported to the Armament Officer. Should it be necessary to remove the gun from the machine for testing it on the Range, the Pilot must always be present while the tests are being carried out.

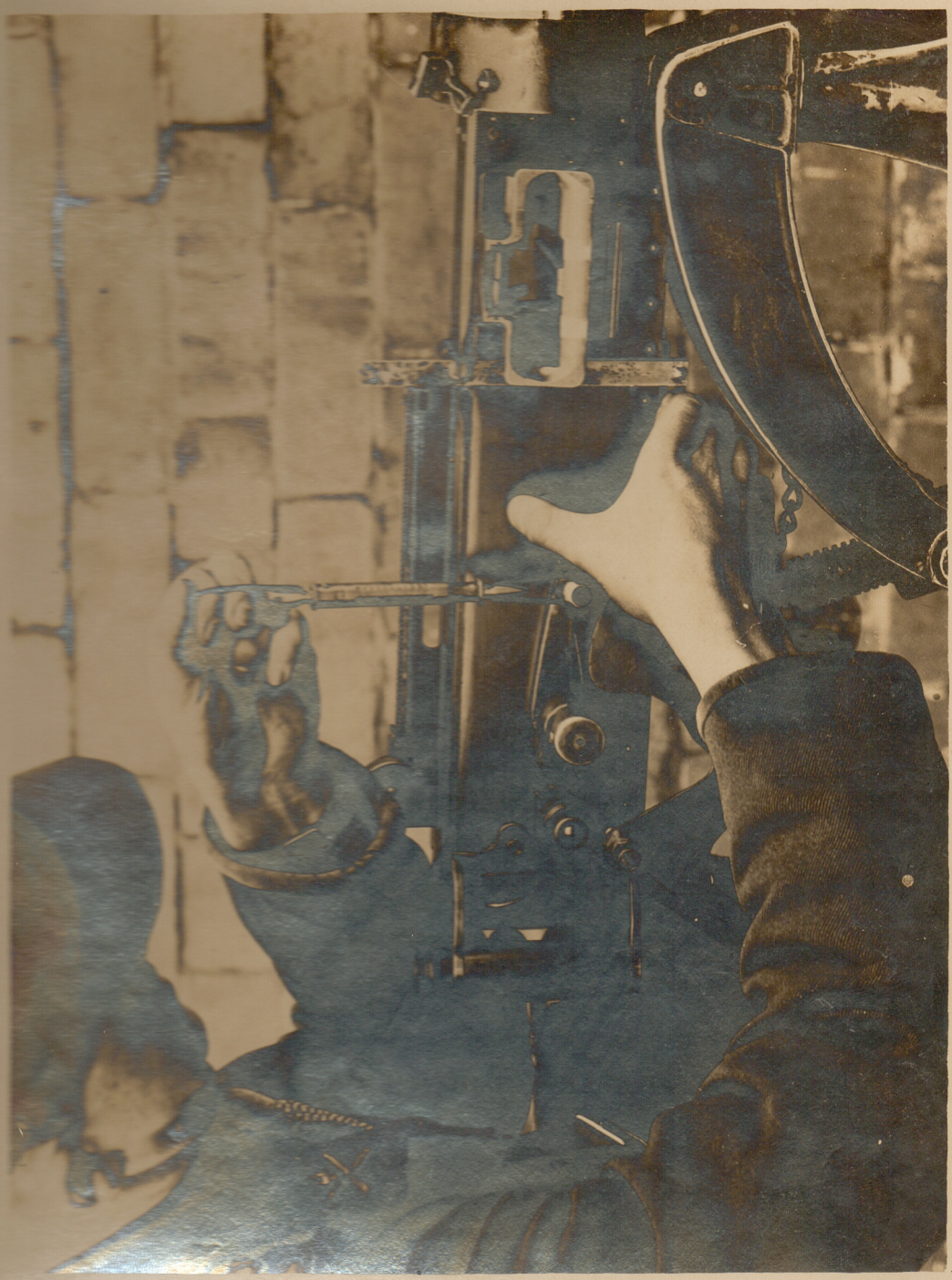
8.—Fill up the History Sheet.

REPAIRS AND ADJUSTMENTS.

Weighing and Adjusting the Fusee Spring.

Remove the lock. Place the loop of the spring balance over the knob of the crank handle. Press down the check lever with the thumb of the right hand. Pull the spring balance vertically upwards, resting the left fore-arm on the breech casing.

The reading indicated when the crank handle commences to move will be the weight of the fusee spring.



Weighing the Fusee Spring.

The weight of the fusee spring should be as follows, viz. :--

With Mk. 1 muzzle cup, - - - - - -	from 9 to 11 lbs.
„ Mk. 2 muzzle cup and ·05 heavy recoil washer,	from 10 to 12 lbs.

If the spring be over or not up to weight adjust by means of the vice-pin. Six clicks (*i.e.*, 3 complete revolutions) in an anti-clockwise direction increases the weight by 1 lb. and *vice versa.*

To weigh the Recoiling Portions.

Put the machine in flying position. Remove the fusee spring. Place the crank handle nearly vertical. Place the loop of the spring balance over the crank shaft and pull slowly to the rear. The pull imparted must be in a horizontal plane. The reading indicated when the crank shaft commences to move will be the weight of the recoiling portions.

For aerial purposes the weight should not exceed 2 lbs.

Testing and Adjusting the Length of the Connecting Rod.

NOTE.—It is unnecessary to carry out this test daily. It should, however, be carried out once a week. Have both the lock in the gun and the spare lock tested.

Remove the fusee spring. Raise the rear cover and pull the crank handle on to the roller. Place an armourer's dummy between the upper and lower projections of the gib. See that the barrel is fully home. Force the crank handle on to the check lever until it is fully home. This places the armourer's dummy in the chamber. Now raise the crank handle about an inch, and again turn it gently towards the check lever; having pushed the check lever back just clear of the crank handle.

If the connecting rod is of the correct length, a slight check will be felt just before the crank handle reaches the check lever.

If no check is felt the lock is not fully home, *i.e.*, the connecting rod is not long enough.

For the purpose of obtaining a fine adjustment in the length of the connecting rod, two sizes of washers, ·003 and ·005 of an inch, are issued. These washers are known as No. 1 and No. 2 respectively.

To adjust the length of the connecting rod—remove the lock. Determine the number of No. 1 or No. 2 washers (or both) required, by first trying a No. 1 on the outer face of the adjusting nut, replacing the lock and re-testing the length, adding washers and again re-testing as found necessary. When the correct length has been determined, remove the washers, unscrew the adjusting nut by means of the combination tool and remove it.

Place the washers on the connecting rod and screw the adjusting nut tightly home on the washers. Re-test to ensure that the adjustment is correct.

From the point of view of Gears, the following should be frequently tested :—

1.—*Weight of Lock Spring.*

2.—*Bents of Sear and Firing Pin.*

3.—*Nose of Trigger and Bent of Tumbler.*

4.—*Side and Extractor Levers.*



Weighing the Recoiling Portions.

To test the weight of the Lock Spring.

Remove the lock and fully cock it. Place the bottom of the lock on a flat surface. Place the loop of the spring balance hard up against the shoulder of the side lever head. Place the left hand on the top of the lock. Draw the side lever head vertically upwards by means of the spring balance. The reading indicated when the side lever head commences to move will be the weight of the lock spring.

The weight should be from 12 to 14 lbs.

For aerial purposes the weight of the lock spring should not be under 12 lbs.

Bents of Sear and Firing Pin.

Remove the lock and fully cock it. Place the bottom of the lock on a flat surface. With the thumb and forefinger of the left hand raise the extractor to the top of its stroke. Force the tail of the trigger to the rear by means of a screw-driver or any other implement.

If the bent of the firing pin has become engaged with the bent of the sear, the firing pin will not be propelled forward by the lock spring.

The Nose of the Trigger and the Bent of the Tumbler.

Remove the lock and fully cock it. Having raised the extractor to the top of its stroke, depress the sear. The firing pin should be held back.

Side and Extractor Levers.

Remove the lock and fully cock it. Place the bottom of the lock on a flat surface. Press down the side lever head slowly.

The extractor should have distinctly risen to the top of its stroke before the bent of the firing pin becomes disengaged from the bent of the sear.

It should be noted that the above simple tests should be carried out not only with the lock used in the gun but also with the spare lock carried in the machine.

Testing of Ammunition.

The extreme importance of carefully testing every round taken up for use, either with the Vickers or Lewis gun cannot be over-estimated. Ninety per cent. of the stoppages occurring in both Lewis and Vickers guns are the direct result of either defective ammunition or want of care and cleaning.

Ammunition for the R.A.F. is now specially manufactured, tested, and packed for issue to Squadrons Overseas. It is nevertheless essential that each and every round is carefully examined and tested before it is taken up into the air.



Weighing the Lock Spring.

Defects to be looked for in Ammunition.

1.—Cracks round the indentations which join the cartridge case to the cannelure of the bullet

2.—Bulged round.

3.—Length of cartridge under or over gauge

4.—Thick rim.

5.—High or deep set cap.

6.—Loose bullet.

7.—Any other unusual feature.

Procedure to be adopted in carrying out the necessary Test for the above Defects.

Every squadron overseas is now provided with one or more "Ammunition Testing Benches." A new Vickers barrel is sunk vertically into the bench (see photo on opposite page). This barrel should be cleaned daily. Near to it should be screwed, face upwards, a good Vickers extractor, from which the gib and gib-spring have been removed.

Above the extractor is placed an arch, provided with a fine adjustment set screw and locking nut, which is gauged to the standard length of the cartridge.

After the cartridge has been cleaned and carefully inspected with the eye, it should be dropped into the barrel to test its diameter, *i.e.*, bulged round.

Each cartridge should go fully home into the chamber without any marked application of force, and be removed easily from the chamber with the middle finger and thumb.

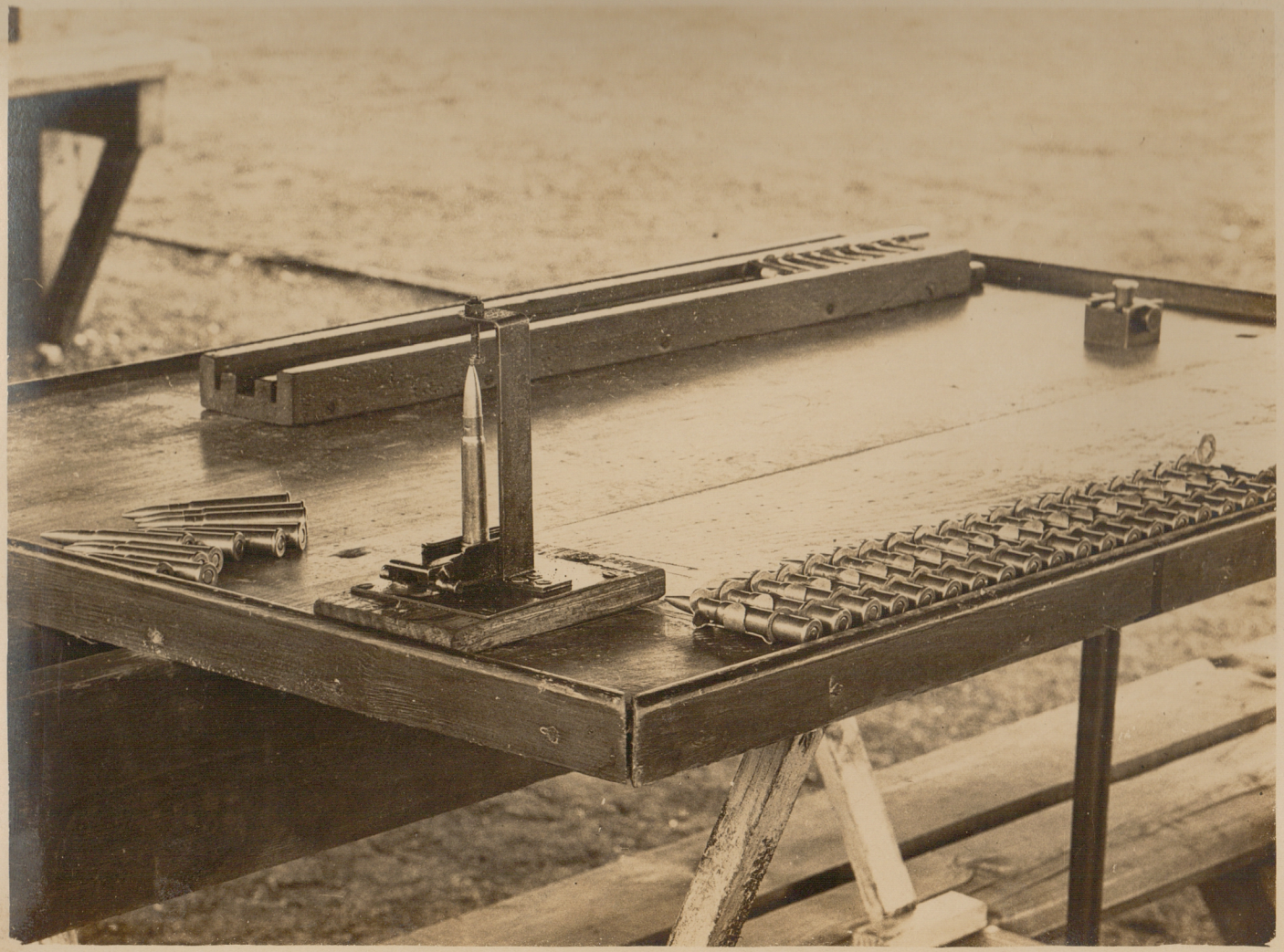
The cartridge should then be slipped along the grooves of the extractor to test for a thick rim. While the cartridge is being passed through the cartridge grooves it should be turned round so that every part of the rim is tested. As the arch mentioned above is fixed directly over the extractor, this process simultaneously tests the length of the cartridge.

If these tests are carefully and systematically carried out, the only gun stoppages likely to occur through defective ammunition are those due to a mis-fire, a badly drawn cartridge case, or a weak charge. The two latter can only be detected on the cartridge being primed.

On return from a flight, all unexpended rounds must be re-tested and the belts re-filled.

Examination of Ammunition Boxes and Chutes.

The following points must be looked to in connection with Ammunition Boxes and Chutes.



Ammunition Test Bench.

Ammunition Boxes.

1.—Boxes must be tightly fixed.

2.—They must be in perfect alignment with the feed-block and lead straight into it.

3.—See that the upper pawls are not fouled by the top edge of the box.

4.—See that the roller is working freely.

5.—The boxes must be examined before and after flight to see that they are not damaged or displaced.

6.—When filling boxes see that the belt is arranged properly in layers.

Chutes.

1.—Chutes must be tightly fixed.

2.—They must be placed exactly opposite the ejection openings for which they are intended.

3.—They must not contain any sharp angles or the gun will be jammed by an accumulation of empties or links.

4.—They must be examined before and after flight to see that they are not damaged or displaced.

5.—They must be clear of the Pilot's feet and all controls.

6.—When special brackets are fitted on the front cover of the gun care should be taken to see that the rivets do not foul the upper lever of the feed-block.

Vickers Gun Stoppages.

The Vickers gun, like any other piece of mechanism, is liable at times, for various reasons, to stop. These temporary stoppages can be cured by the Pilot by carrying out certain simple actions which are known as "Immediate Action," or I.A.

I.A. is defined as "the instant application of a probable remedy for a stoppage based on the position of the crank handle."

This Immediate Action should take the form of a purely instantaneous mechanical action on the part of the Pilot involving no waste of time in thought and involves no knowledge whatever of the cause of the stoppage.

When the application of the correct I.A. has become automatic it is necessary that the Pilot should then thoroughly grasp the causes of the various stoppages.

It should, however, be clearly understood that the automatic application of the correct I.A. should first be attained before the question of the causes of stoppages is touched.

The instantaneous application of correct I.A. can only be attained by constant practice.

Immediate Action.

The position of the crank-handle acts as an indication of the Immediate Action necessary to remedy any particular stoppage. For instructional purposes the stoppages are known as No. 1, No. 2, No 3, and No. 4 stoppages.

The following table of temporary stoppages, set out in four columns, shews in

Column 1— The four positions of the crank-handle when the gun stops firing. The second and third positions may vary slightly. The position of the crank handle forms the ready indication of the I.A. to be applied.

Column 2 gives a detailed description of the I.A. to be performed by the Pilot.

Column 3 gives the probable causes of the stoppages.

Column 4 gives the method of preventing the occurrence of certain stoppages. They can, as a general rule, be prevented by the careful examination and preparation of the gun, link belts, and ammunition before a flight.

Stoppage No. 1.

Position of Crank Handle.	Immediate Action.	Probable Cause.	Prevention of Occurrence.
Crank-handle vertical.	A. Pull crank-handle on to roller. Let go. Fire.	A. 1. Defective Ammunition, Weak charge. Deteriorated Ammunition. 2. Tight packing in Links.	A. 1. Cannot be provided against. 2. Correct gauging of ammunition and filling of belts.
	B. If failure recurs repeat A until gun is warm.	B. Excessive friction due to congealed oil.	B. Fire occasional short bursts.
	C. Stoppages arising from causes given in this group cannot be remedied in the air.	C. 1. Weight of fusee spring excessive. 2. Worn barrel. 3. Friction on working parts. 4. Packing of cannelure too tight.	A high standard of training of Armourers and Pilots should prevent these occurring, particularly if the points before flight have been carefully carried out.

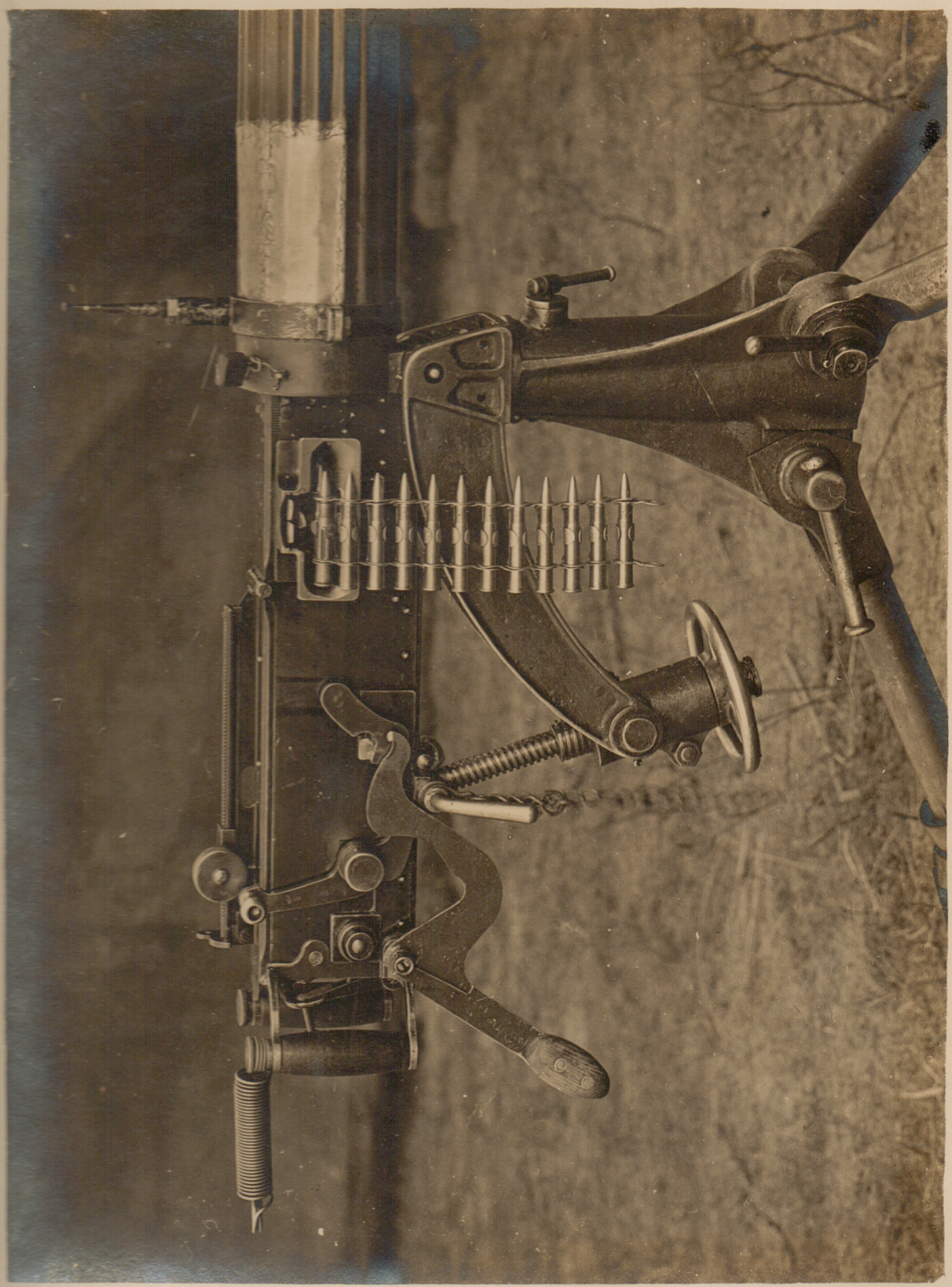
NOTE.—It will be seen that a No. 1 stoppage is caused either by insufficient force of recoil or excessive friction. The recoiling portions are accordingly not driven far enough back, and the horns of the extractor are caught in the steps in the solid cams. Feed has, however, taken place, and a live round is therefore in position in the feed block up against the cartridge and bullet stops.

The steps in the solid cams are therefore a safety device to prevent the lock going forward and the live round gripped between the upper and lower projections of the gib from priming the live round in the feed block.

Stoppage No. 2.

In this case the crank handle may stop, with the knob in any position, from level with the rear cover down to level with the top of the check-lever. This stoppage has, for aerial purposes, been eliminated for the following reasons:—The causes of this stoppage are, first, a bulged round and, secondly, a separated case. If the ammunition tests, as previously given, have been carefully and systematically carried out, a bulged round should never be present in a belt Again, it is impossible to get a bulged round into a Prideaux link belt which has been carefully filled.

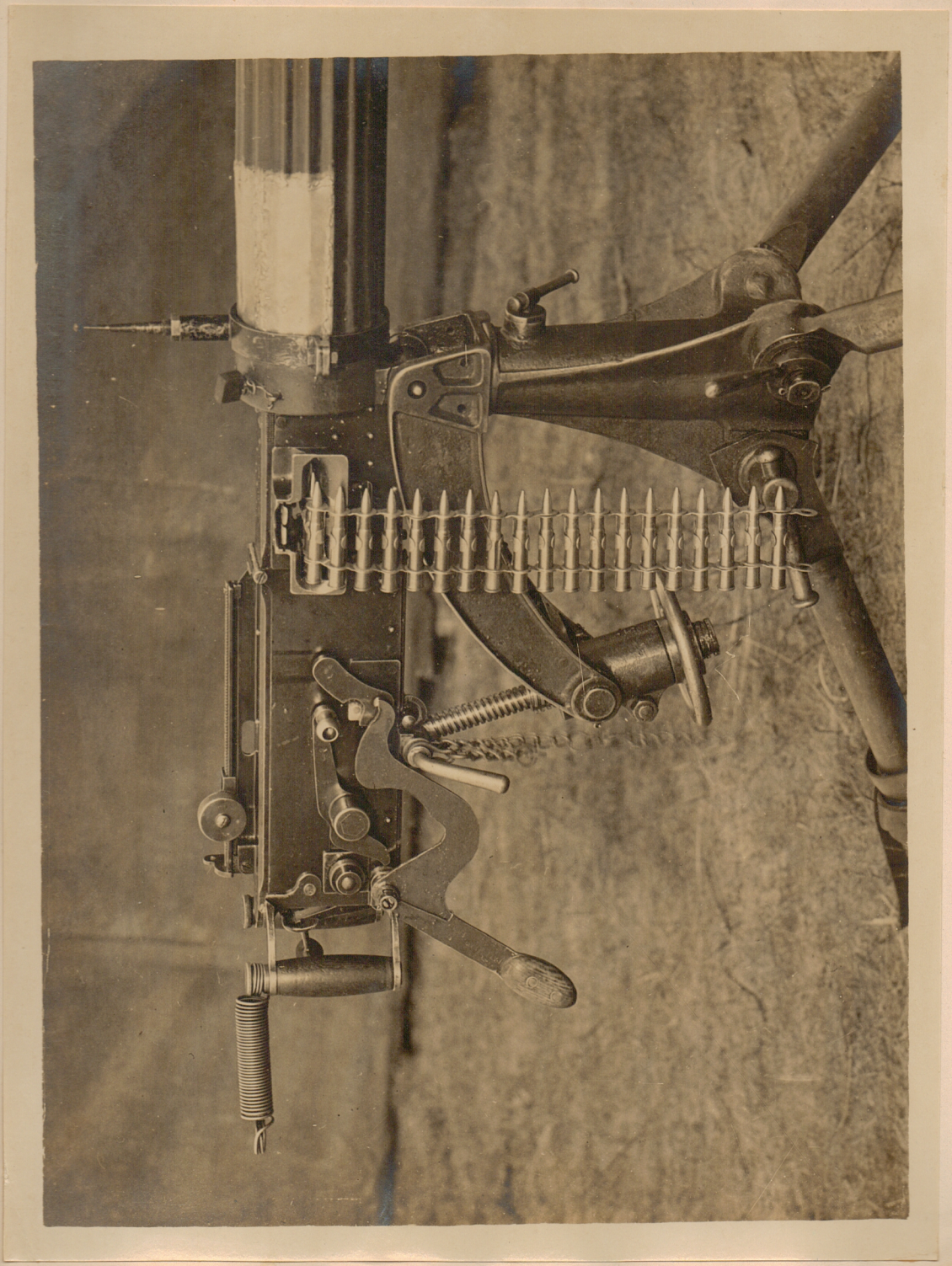
The great care taken in the manufacture of ammunition for R.A.F. use overseas practically eliminates a separated case being caused by defective ammunition, *i.e.*, by a badly drawn cartridge case. A separated case can, however, be caused by the connecting rod not being long enough. It is for this reason that under the heading of "Repairs and Adjustments" the sub-head "Testing the Length of the Connecting Rod" is emphasized.



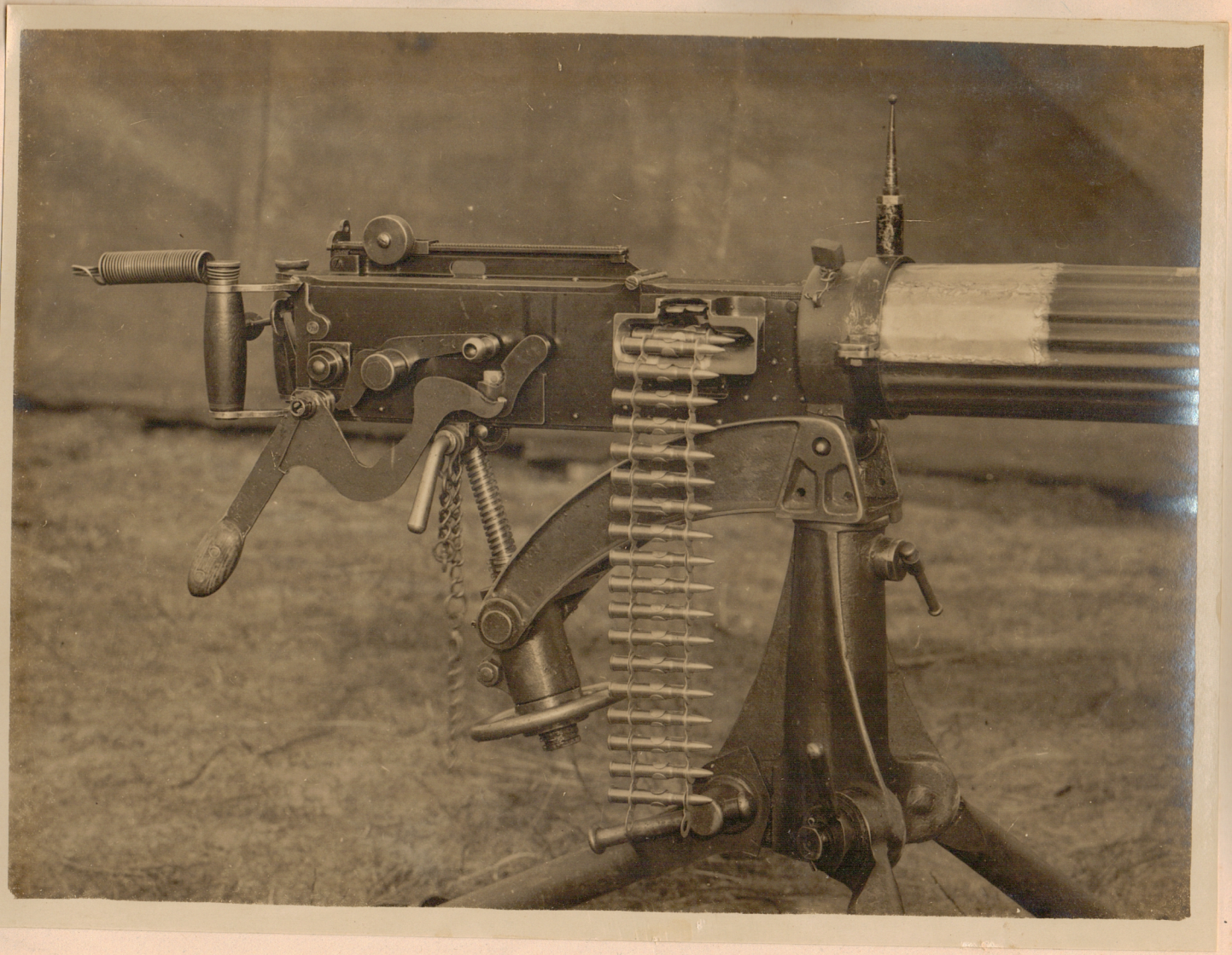
No. 1 Stoppage.

Stoppage No. 3.

Position of Crank-handle.	Immediate Action.	Probable Cause.	Prevention of Occurrence.
Crank-handle may stop in any position from the top of the check lever to practically on but clear of the check-lever.	A. Strike down crank-handle. Continue firing. Should stoppage recur, repeat I.A. until gun is warm.	A. 1. Excessive friction due to congealed oil. 2. Friction on lock obstructing upward movement of extractor.	A. 1. Fire an occasional short burst during flight while not in action. 2. High standard of training of armourers. (Inspection of lock).
	If A. fails look at the pawls.		
	B. Pawls not protruding. Engage Foroto spring on crank-handle. Slightly raise crank-handle. Push belt into correct position in the feed block. Disengage Foroto spring. Strike down crank-handle. Fire.	B. 1. Slight cross-feed. 2. Slightly mis-shapen link.	B. 1. Correct loading action. 2. Inspection of links while filling belts.
	C. If pawls are protruding, Engage Foroto spring on crank-handle. Draw back crank-handle. Raise rear cover. Remove first round in the feed block by means of Foroto jam clearer. Remove Foroto spring from crank-handle. Close rear cover. Half load. Fire.	C. Double feed due to bad loading.	C. High standard of training in the loading of the gun.



No. 3 A. Stoppage (Friction)



No. 3 B. Stoppage (Slight Cross Feed).



No. 3 C. Stoppage. (Double Feed).

Notes on No. 3 Stoppages.

No. 3 C.—Should the round removed from the feed block by means of the Foroto jam clearer fall into the breech casing, it will be found that, on removing the Foroto spring from the knob of the crank handle, the lock will not go home.

To remedy this, pull the crank handle on to the roller and slightly raise the lock. The surplus round in the breech casing will then fall out and, on releasing the crank handle, the lock will go fully home.

To complete the Immediate Action proceed as detailed in the latter part of No. 3 C.

A No. 3 Stoppage may also be caused by a "thick rim." If the ammunition tests, as previously detailed, have been carefully and systematically carried out, a thick rimmed cartridge should not be present in the belt. The clearing of this stoppage is of an awkward nature, again emphasizing the extreme importance of carefully carrying out all ammunition tests.

Stoppage No. 4.

Position of Crank Handle.	Immediate Action.	Probable Cause.	Prevention of Occurrence.
Crank Handle on Check Lever.	With C. C. Gear :—		
	If Reservoir Handle is down,	Loss of pressure in	
	Pull up Reservoir Handle.	High Pressure Reservoir.	
	If Reservoir Handle is up,		
	A. Half Load.	A. Misfire, *i.e.*,	
	Fire.	Defective Ammunition.	
		— — —	No means of
	B. If A. fails,	B 1. Damaged or broken firing pin.	detection.
	Unload.		
	Change Lock.	2. Broken lock spring.	
	Reload.		
	Fire.		

The following would cause prolonged stoppages :—

1.—Loose or broken muzzle cup.

2.—Broken gib or gib spring.

3.—Broken fusee or fusee spring.



No. 4 Stoppage.

In the event of one of these breakages taking place the Pilot would necessarily be compelled to break off the fight.

The following would bring about a run-away gun :—

1.—Broken nose of the trigger.

2.—Broken bent of the tumbler.

3.—Breakage of the short arm of the lock spring about one quarter of an inch from the end.

In the event of one of these occurring, the gun would fire automatically without being controlled by the gear.

To stop the gun firing, use the loading handle to prevent the crank handle from going fully home.

This action necessarily brings the front portion of the loading handle into contact with the crank handle, thus giving a No. 3 stoppage.

Care and Cleaning.

To obtain the maximum efficiency from the Vickers gun it is essential that it be maintained in perfect condition. A very large percentage of the stoppages which occur, both in the Vickers and the Lewis, are due to want of care and cleaning.

It is, therefore, clear that the vital importance of the very strictest attention being paid to care and cleaning cannot be overestimated.

Our most successful Pilots, viz. :—Capt. Ball, Major Bishop, Capt. Fullard, Capt. M'Cudden, Capt. Rhys-Davids, and many others, realising the importance of this, always cleaned and looked after their own guns.

Careful attention to this subject naturally results in a Pilot getting a marked increase of confidence in his gun, and he goes into a fight with a proportionate increase in confidence with the assurance that his gun will open fire at the instant that he wishes it to do so, and will continue to fire as required, any isolated temporary stoppage which does occur not being attributable to want of care and cleaning.

General Points.—The following points should be carefully noted :—

1.—Guns must be examined daily after cleaning.

2.—Avoid damage to the gun through careless handling.

3.—Never play with the crank handle unless the lock is in the gun. The reason for this is that the interrupted flange of the connecting rod dents the bottom plate.

4.—Never keep the lock spring compressed unnecessarily.

Oil to be used.—The oil to be used is of a special description, viz.:—Machine Gun Oil for low temperatures, and is generally known as P924.

This oil has been adopted after a long series of experiments, as the service oil is liable to coagulate at low temperatures and thus interfere with the free working of the gun.

It has sufficient viscosity to ensure adherence to the working parts, yet, at the same time, it is of such a thin nature that it has been found not to clog the working parts at a temperature of 11 deg. F. P924 must be used in the winter months. During the summer months a mixture of equal parts of oil, lubricating G.S. and P924, must be used.

It is most important to note that, owing to the extremely low temperature at high altitudes, particularly during the winter months, too much oil must on no account be applied to the gun.

The cleaning of the gun is carried out to remove the fouling produced principally by the chemical combustion of the cordite in the cartridge case.

Fouling may be said to be of three kinds, viz. :—

1.—Superficial Fouling.

2.—Internal Fouling.

3.—Metallic Fouling (Nickelling).

Superficial Fouling.—This type of fouling is caused by the solid products of combustion being deposited on the bore of the barrel.

Internal Fouling.—This type of fouling is caused by the harmful gases, resulting from the chemical combustion of the cordite, penetrating the pores of the bore of the barrel while it is hot.

Metallic Fouling (Nickelling).—This type of fouling is caused by minute portions of the cupro-nickel envelope being left in the bore. It appears as a whitish streak on the lands or as a roughness on the edge of the grooves. If deposited near the muzzle or the breech, it is visible to the naked eye when the bore is clean, but it can only be detected in the vicinity of the centre of the bore by means of the gauge plug.

It is a cause of inaccuracy, and, if the gun shoots badly for no apparent reason, its presence should be looked for as a possible explanation.

The presence of metallic fouling in the bore markedly increases the friction generated by the bullet passing through the bore resulting not only in diminution of the muzzle velocity (causing inaccurate shooting), but also in a marked increase in the wear of the bore.

Wear of the bore in machine guns is due to three causes, viz. :—

1.—The friction generated by the passage of the bullet down the bore.

2.—The heat generated by the chemical combustion of the cordite.

3.—The friction generated by the use of the double pull-through gauze.

Careful care and cleaning will not only diminish friction, but will also render the frequent use of the double pull-through unnecessary. The interior of a new barrel carries a high polish which is a safeguard against rust and metallic fouling. It must, however, be recognised that, as the barrel becomes worn, this polish will tend to diminish. Efforts to restore it by the use of the double pull-through merely result in unnecessary wear. Though the polish may tend to diminish, it must be clearly understood, however, that the lands must be bright and free from erosion or fouling. - - - - -

Removal of Fouling.

Fouling may be removed by the following means :—

Superficial Fouling.—This is readily removed, when warm, by the use of a cleaning rod and flannelette. If it is allowed to remain in the barrel for any length of time, it "cakes" or becomes hard and has a corrosive effect equal to that produced by internal fouling.

It is for this reason that if, on returning from a flight, it be impossible for the Armourers to clean the gun immediately, it is essential that an oily 4 by 2 be immediately pulled through the bore. The film of oil thereby put on prevents the superficial fouling from caking.

Internal Fouling.—This may be removed satisfactorily by the use of boiling water. If this method is not employed, the barrel will "sweat" and a hard black crust of fouling will appear in the bore. This will turn to rust if not removed, and the barrel will then require repeated cleanings with flannelette and with gauze for a time that will vary according to climatic conditions and the state of the bore. Before boiling water is used, all superficial fouling and grease should be carefully removed. No definite quantity of water to be used can be given, but the most satisfactory general rule to follow is to continue pouring boiling water down the bore until the barrel is too hot to be held with comfort with the naked hand. Before this is done the barrel should be removed from the gun. The bore should then be thoroughly dried and oiled.

Not only does the boiling water remove the fouling, but the expansion of the metal, due to the heat of the water, loosens any rust there may be, and makes it easily removable.

Metallic Fouling (Nickelling).—This type of fouling is removed by the use of the double pull through, or by K.N.S., *i.e.*, Kynoch's Nickel Solvent.

The actual procedure to be adopted in the cleaning of the gun may be divided into two major sub-heads, viz.:—

1.—Daily cleaning.

2.—Weekly cleaning.

The sub-head "Daily cleaning" may again be divided into two minor sub-heads, viz. :—

1.—After firing less than 600 rounds.

2.—After firing more than 600 rounds.

Daily cleaning.—After firing less than 600 rounds.

Remove the recoiling portions. Clean the barrel with the rod, 4 by 2, and oil. Clean the outside of the gun and all parts of the mechanism with a clean but oily rag.

After a careful examination of all parts, wipe every part dry, re-oil and re-assemble.

To clean the mechanism.—To do this a mixture of equal parts of oil, lubricating G.S. and paraffin should be used. Should any parts be clogged with dried oil, spirits of turpentine should be used to remove it. After each part has been oiled it should be thoroughly dried and re-oiled.

The lubricating oil should, in warm weather, be a mixture of equal parts of oil, lubricating G.S. and P924, while in cold weather P924 only should be used.

Hanging the lock and working the recoiling portions affords a ready means of oiling the recoiling portions and the bearing parts of the barrel, *i.e.*, just in front of the barrel block—which can only be got at by removing the feed block—and at the muzzle end in front of the packing gland.

When paraffin has been used, all traces of it should be carefully removed, as paraffin, though an efficient aid for removing rust, does not prevent its formation.

After firing more than 600 rounds.

The method to be adopted in cleaning the gun in this case is exactly the same as that followed in "After firing less than 600 rounds," with the addition that internal fouling should be carefully removed in the manner previously detailed.

Weekly cleaning.—The gun should be thoroughly overhauled and cleaned once a week, and examined by the Squadron Armament Officer.

How to use the Cleaning Rod.—Insert a piece of oily flannelette into the eyelet of the cleaning rod. See that the flannelette surrounds the cleaning rod. Insert the cleaning rod from the muzzle and fix the movable bush. Work the rod backwards and forwards centrally with the axis of the bore. Should it be found difficult to withdraw the rod, no cross stress should be applied, otherwise the rod will snap. Remove the oily flannelette and replace it by dry flannelette, four by two. Finally, leave bore slightly oiled.

How to use the Double Pull-through.—Place the gun metal protector on the muzzle in order to keep the cord central. Fix the barrel in a vice or have it held firmly by one man, while two others, helping with their free hands to keep the barrel steady, pull the cord backwards and forwards until the fouling or rust is loosened. When the gauze is worn out, it should be replaced by one of the spare pieces which are issued with each double pull-through.

When the cord shews signs of wear, a new one should be taken into use to avoid the risk of the double pull-through breaking in the bore. If breakage does occur the barrel must be taken at once to the Armourer Sergeant. No attempt must be made by the Pilot to remove it.

How to put on a Gauze.—As has already been explained it is necessary, to remove metallic fouling, to use the double pull-through.

For this purpose wire gauze, in pieces 2½in. by 1½in., is supplied.

In attaching the gauze the following principles should be applied, viz. :—

In attaching the gauze to the pull-through, turn the shorter sides towards the upper so that the larger sides take the form of an "S." Open the loop of the pull-through and put one side of it in each loop of the "S." Then coil each half of the gauze tightly round the portion of the cord over which it is placed, till the two rolls thus formed meet.

The object of the gauze is, mainly, to scour out the grooves, and it should, therefore, fit the bore tightly. When it fails to do this it should be partially unrolled and packed with paper or flannelette to increase its bulk. On no account must matches or small pieces of wood be used for this purpose.

Grit must be removed from the gauze and the pull-through before use, and the gauze should be *thoroughly oiled.*

Cleaning with the gauze entails wear of the bore. The gauze should not, therefore, be used more than is absolutely necessary.

The surest way of preventing the necessity of the continual use of the double pull-through is to pay the most careful attention to daily care and cleaning, and to keep the bore well oiled to prevent rust.

A barrel which has become rusty will always be more liable to rust than one which has been kept in good condition. It will, therefore, require more attention and more frequent cleaning with gauze.

Similarly, a barrel in which erosion has commenced will require more care than one of which the surface has not been attacked, for, the corroded portion being rough, moisture is more likely to collect on it and form rust. Combined with this it is more difficult to remove rust from a rough surface than it is from a smooth one.

Instructions for Filling Mark I. and Mark II. Articulated Links.

Belts made up with these links, if carefully filled and *handled*, give very little trouble ; but if carelessly filled and handled, slight cross feeds are nearly sure to occur.

Mark I. Pattern.—The metal forming each half of the *rear* portion of the link is stamped flat.

Mark II. Pattern.—The metal forming one half of the *rear* portion of the link is stamped flat, but the other half hastwo indentations stamped in it.

Both Mark I. and Mark II. patterns have an indentation stamped in one half of the *front* portion of the links.

Mark I. and Mark II. Patterns must not be joined together in the same belt.

Filling the Belt.

1. Place on a table, with the claws uppermost, a number of the links interlaced ready to receive the cartridges.

2. See that the front and rear portions of the links are in an upright position—*i.e.*, they must not be leaning towards or away from the claws.

3. The face of each link must bear *closely* against the face of the next.

4. Push the cartridges into the links until the front edge of the case just touches the indentation on the front portion of the link.

5. If a cartridge is a very tight fit in the links it is caused by :—

(a) The claws being too close together.

(b) The hole in the front portion of the link being too small.

To Remedy.

(a) Open out the claws a little with a screw-driver.

(b) Flatten out slightly the indentation in the *front* portion of the link by squeezing it gently with a pair of pliers.

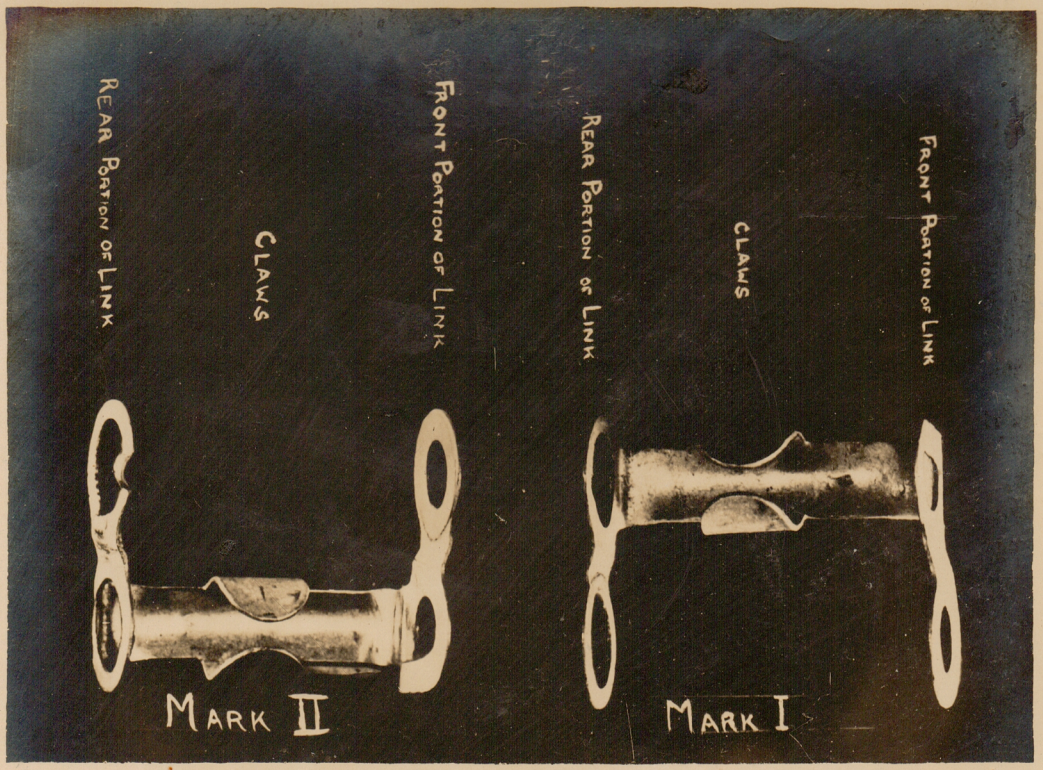
6. Test by gently pulling at the base of each cartridge to see that they do not fit loosely in the links.

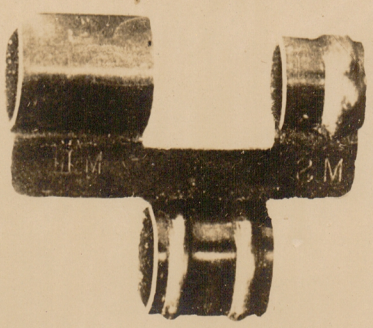
If any cartridge is loose, take out that cartridge and slightly close the claws of that particular link ; then replace the cartridge.

NOTE.—*Mark I. Pattern* should be fed into the feed block with the claws uppermost.

Mark II. Pattern should be fed in with the claws turned downwards.

Care in Handling.—After a belt has been passed as filled correctly it must be handled very carefully to avoid loosening the cartridges or distorting the links.


FRONT PORTION OF LINK
CLAWS
REAR PORTION OF LINK
MARK I
FRONT PORTION OF LINK
CLAWS
REAR PORTION OF LINK
MARK II


FRONT PORTION OF LINK
1M
2M

PRIDEAUX

Instructions for Filling Prideaux Links.

Filling the Belt.

1. Place on a table a number of the links interlaced ready to receive the cartridges.

2. Push the cartridges into the links until the shoulder of the cartridge case meets the front portion of the link.

3. If a cartridge is a very tight fit in the links, it is usually caused by the front portion of the link being closed in a little too much.

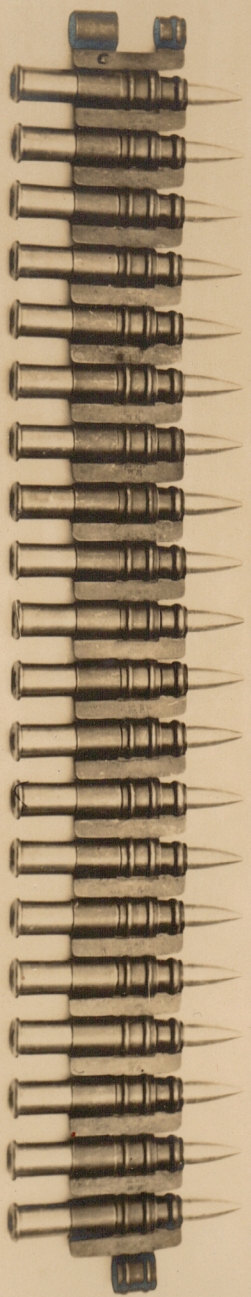
This fault can usually be remedied by forcing open with a screw-driver the front portion of the link.

4. Test by gently pulling at the base of each cartridge to see that they do not fit loosely in the links.

If any cartridge is loose, take out that cartridge and slightly close the front portion of that particular link, and then replace the cartridge.

NOTE.—Belts made up with this type of link should be fed into the feed block with the double-ended portion leading (that is, in the direction of the arrow).

Care in Handling.—The same remarks apply as to Mark I. and II. pattern links.



Deflection and Theory of Sighting generally.

The Theory of Sighting as applied to Aerial Gunnery differs considerably from that applying to Ground Gunnery.

In ground work fighting takes place between combatants one of whom—the firer—is, in the great majority of cases, stationary, and the other—the target—may be stationary or moving at a slow and more or less constant speed in the same horizontal plane as the firer. Aerial combats, however, taking place as they do between combatants both of whom are possessed of considerable and variable speed, and whose relative paths are therefore incessantly changing every fraction of a second, involve problems in sighting, or the application of corrections in sighting, which are of paramount importance.

Again, as has been pointed out, in ground fighting the gunner is practically always stationary, and the target may or may not be in motion, and it is, therefore, clear that in this case allowance has to be made for the movement of the target only.

In aerial gunnery, however, both the gunner and target are possessed of considerable speed, and should the gun be firing at an angle to the path of flight of the firer, allowance has to be made for the movement of both.

In the application of corrections in sighting for aerial gunnery, as indeed for gunnery of all descriptions when fire is being directed on a moving target by a gunner, who may or may not be stationary, the allowance which has to be made is for the movement of the target relative to the gunner.

This is an obvious fact, but is perhaps clearly illustrated by considering the case of a gunner firing at a moving target, both gunner and target being on the same moving platform.

The allowance which the gunner has to make is dependent solely on the rate of movement of the target, and this allowance is obviously independent of the rate of movement of the moving platform.

The point to be noted in this illustration is that both the target and the gunner are on the same moving platform, and therefore the movement of the target relative to the gunner is in no way affected by the movement of the platform.

Exactly the same principle holds good in aerial gunnery. It can be quite easily proved by elementary dynamics that the rate of change of position of one machine relative to another—and it is for this relative rate of change of position that allowance has to be made in aerial gunnery—is independent of the velocity of the wind.

The only assumption which it is necessary to make to complete the analogy is that both machines are flying in a wind which affects them equally, both in magnitude and direction. At the ranges at which aerial combat takes place—a range which rarely exceeds two hundred yards—it is obvious that although this assumption may introduce errors, they will, however, be so small, that for practical purposes they may be ignored.

The two principles, therefore, to be established, are that the allowance which has to be made is for the rate of change of position of the hostile aircraft relative to the firer, and that this rate is independent of the velocity of the wind.

The guns in use in the R.A.F. may be conveniently arranged—according to their method of laying—under two sub-heads :—

1.—Fixed Guns. 2.—Movable Guns.

The movable gun is used almost entirely by Observers and therefore will not be considered.

For the Pilots' use guns are so mounted that they fire along or parallel to the path of flight of the firer.

In this case it is unnecessary to make any allowance for the speed of the firer, and allowance has accordingly to be made for the speed of the hostile aircraft only.

To enable the Pilot to make the necessary allowance for the speed of the hostile aircraft the Ring Sight is used.

The Ring Sight.

This sight consists of two concentric rings, 5in. and 1in. in diameter respectively, with four radial wires joining the inner and outer rings.

It can be used either as a fore sight with a fixed bead back sight, or as a back sight with a fixed bead fore sight. In either case the radius of the outer ring is correct for use against an enemy aeroplane travelling at 100 miles per hour, when the ring is thirty-eight inches from the firer's eye.

To enable the importance of these figures and the principles underlying the use of the Ring Sight to be clearly understood it is necessary to demonstrate by diagrams and very elementary geometry the data on which this sight is designed and the fundamental principles on which its use is based.

In all that follows it is assumed that Mk.VII. or Tracer Ammunition is used.

Let Fig. 1 represent a diagrammatic plan of the ring sight.

"A" represents the firer's eye, B C D the ring sight, A C G an imaginary straight line passing through the firer's eye, the bead and the centre of the small ring of the ring sight.

C D then represents the radius of the ring sight. A B E and A D F represent rays of light passing through the firer's eye and cutting the larger circle of the ring sight. It is assumed that the range is 200 yards, *i.e.*, the maximum range at which aerial combats will, in the great majority of cases, take place. It is also assumed that the path of flight of the bullet is a straight line and that its muzzle velocity is 2240 feet per second, and is constant over the range in question.

Theoretically this is not correct, but the errors introduced thereby are so small that, for practical purposes, they may be ignored.

It is, therefore, assumed that the bullet travels along or parallel to the line A C G. A C G then represents the path of flight of the firer, and it should be noted that B C D—*i.e.*, the horizontal diameter of the ring sight as seen in plan—is perpendicular to the path of flight of the firer.

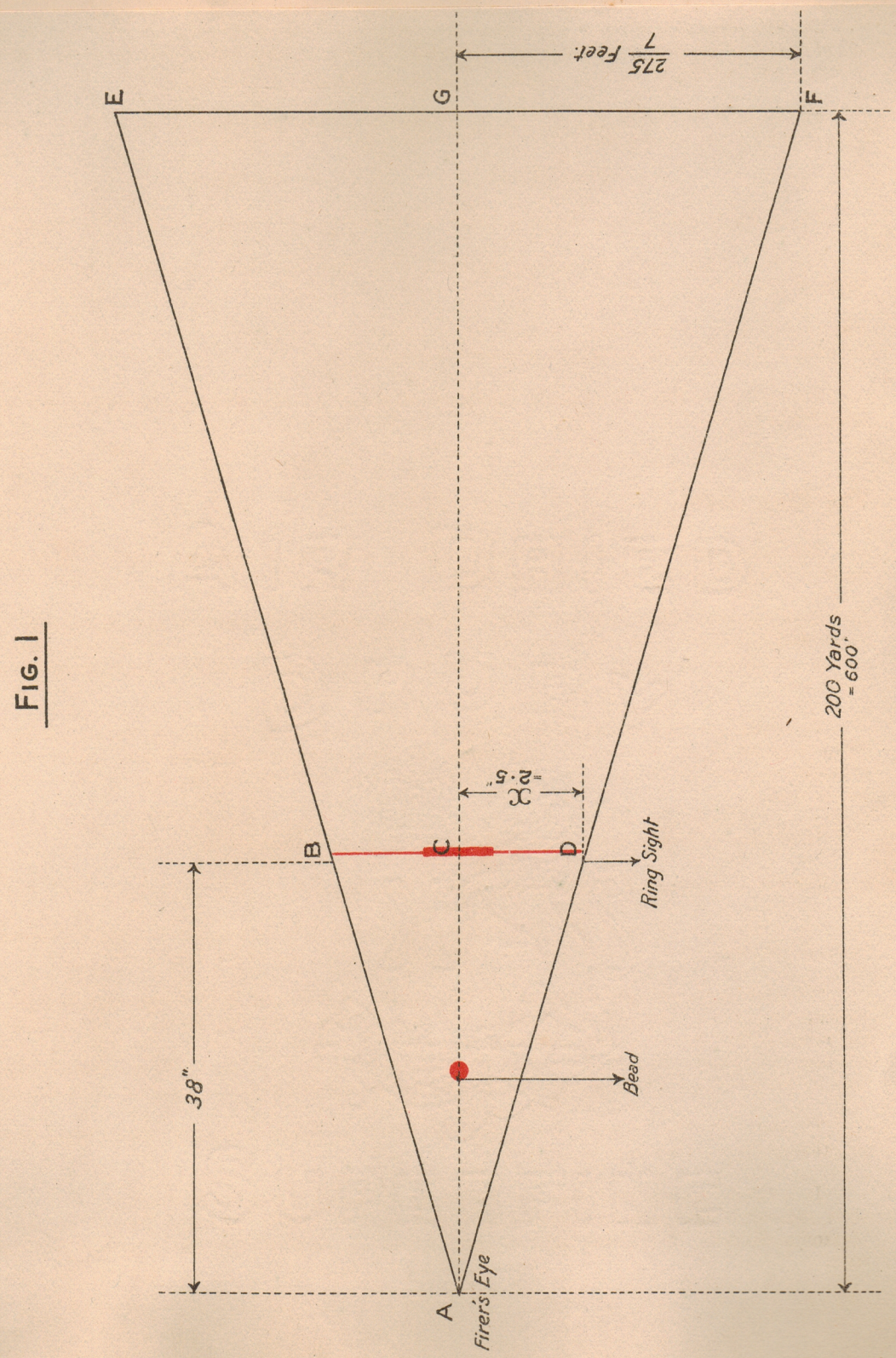

E
G
F
275/7 Feet.
200 Yards = 600'.
38".
B
C
D
Ring Sight
Bead
A
Firer's Eye

FIG. I

Now the time taken by the bullet to cover a range of 200 yards is equal to

$$\frac{\text{Range in feet.}}{\text{Muzzle velocity of bullet in feet per sec.}} = \frac{200 \times 3}{2240} = \tfrac{15}{56} \text{ sec.}$$

Let us assume a 100 M.P.H. hostile aircraft to be at F, flying in the direction F G—*i.e.*, at right angles to and flying towards the path of flight of the firer.

What it is desired to determine is the value of C D—*i.e.*, the magnitude of the radius of the ring-sight.

It is first necessary, however, to determine the distance in feet covered by the hostile aircraft in the time taken by the bullet to traverse 200 yards.

To reduce the velocity of the hostile aircraft, given as 100 M.P.H., to feet second units, it is necessary to multiply 100 by 5280 to bring it to feet and then divide by 60×60.

The velocity of the hostile aircraft in feet second units therefore is

$$\frac{100 \times 5280}{60 \times 60} = \frac{100 \times 22}{15} = \left\{100 \times \frac{22}{15}\right\} \text{ feet per sec.}$$

But, as we have previously seen, the time taken by the bullet to traverse 200 yards is $\frac{15}{56}$ sec.

It is therefore clear that in this interval of time the enemy aeroplane will cover

$$\left(\frac{100 \times 22}{15} \times \tfrac{15}{56}\right) \text{ Feet.}$$

$$= \frac{275}{7} \text{ feet}$$

This distance, it should be noted, is at right angles to the path of flight of the firer.

Now let x = radius of the ring-sight in inches.

As C D is parallel to F G, the triangles A C D and A F G are similar.

Therefore $\frac{C D}{A C} = \frac{F G}{A G}$

Substituting in this equation we get

$$x = A C \times \tfrac{F G}{A G} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.$$

$$= \frac{38 \times 275}{600 \times 7} = \frac{209}{84} = 2{\cdot}49 \text{ inches.}$$

The diameter of the ring-sight therefore is

$$= 2{\cdot}49 \times 2$$
$$= 4{\cdot}98 \text{ inches.}$$

This gives the internal diameter of the larger ring of the ring-sight. This larger ring is constructed of sheet metal, making the external diameter of the ring-sight 5″.

On examination of Fig. 1 it will be noted that the dimensions of the ring-sight were determined on the assumption that the range was 200 yards.

It is clear, however, that, for any intermediate range, as the condition of similarity of triangles still exists, the dimensions of the ring-sight are independent of the range.

This, therefore, establishes the important principle that, for the ranges at which aerial combats take place, the position of the hostile aircraft in the ring-sight is independent of the range.

It should be noted, however, that this is true only for moderately short ranges, for the following reasons, viz. :—

In the above proof it was assumed first that, for the comparatively short ranges in question, the path of flight of the bullet was a straight line, and secondly that the velocity of the bullet during its flight was constant. As the range markedly increases, these assumptions cease to be justifiable, as, due to the force of gravity, the path of flight of the bullet ceases to be a straight line and tends to become more and more of a parabolic nature, in addition to which, due to head resistance, the velocity of the bullet appreciably diminishes.

On referring to Fig. 1 it will be noted that A C G passes through the firer's eye, the fixed bead, and the centre of the ring-sight.

In using the ring-sight, therefore, this condition must in every case be complied with.

The bead, which is as a general rule placed approximately midway between the firer's eye and the ring-sight, is attached to enable the firer to place his eye on this imaginary straight line. Without the bead this would be impossible.

Again, it will be noted that the firer's eye must in every case be a definite distance—*i.e.*, 38 inches—from the ring-sight.

Lastly, in the case discussed, it was stated that the hostile aircraft was flying at right angles to the path of flight of the firer and in the direction F G.

That is to say, the enemy aeroplane is flying towards the line A C G, or, in other words, towards the centre of the ring-sight.

It is therefore clear that in using the ring-sight the three conditions given below must in every case be most rigidly fulfilled :—

1.—*The firer's eye, the bead and the centre of the ring-sight must be in one straight line, or, in other words, the bead must be central.*

2.—*The firer's eye must be a definite distance—viz., thirty-eight inches—away from the ring-sight.*

3.—*The hostile aircraft must be flying towards the centre of the ring-sight.*

The importance of rigidly fulfilling the above conditions will be seen from the following examples :—

Consider Condition 1.—Let us assume that the firer moves his eye half an inch to the RIGHT of the line passing through the centre of the ring-sight and the bead.

It can be quite easily proved that, at a range of 200 yards, this movement of the firer's eye results in 7 ft. 8½ in. insufficient deflection being allowed for a hostile aircraft crossing the path of flight of the firer from the right, and 8 ft. too much deflection being allowed for a hostile aircraft crossing the path of flight of the firer from the left. Exactly the same principle holds if the firer's eye is moved to the left. Insufficient deflection is then allowed for a hostile aircraft crossing the path of flight of the firer from the left and excessive deflection being allowed for a hostile aircraft crossing the path of flight of the firer from the right.

Similarly, if the firer's eye is moved half an inch above the line passing through the centre of the ring-sight and the bead, the path of flight of the hostile aircraft is thrown 8 feet (very nearly) below the line of fire, and *vice versa.*

Now consider Condition No. 2.—Let us assume that the firer moves his eye to 30 inches from the ring-sight. It can be quite easily proved that this results in 10 feet 8½ inches too much deflection being allowed.

Similarly, if the firer's eye is moved to 50 inches from the ring-sight, the deflection allowed for a 100 m.p.h. hostile aircraft is insufficient by 9ft. 4in.

It is therefore clear that a movement of the firer's eye towards the ring-sight results in excessive deflection being allowed, and *vice versa.*

Condition No. 3 is an axiom which, therefore, requires no further illustration.

We have so far discussed only the case of the hostile aircraft crossing the path of flight of the firer at right angles and have proved that under these circumstances *the pilot's seat of the hostile aircraft should be cut by the outer circumference of the ring sight.*

We have still, however, to deal with the general case in which the hostile aircraft is crossing the path of flight of the firer at an angle other than 90°.

Before dealing with this case let us examine Fig. 1.

In this Figure it will be noted that B C D is perpendicular to A C D. In other words, the transverse diameter of the ring sight is at right angles to the path of flight of the firer. F G must therefore be perpendicular to A G. Now F G is the necessary deflection to be allowed.

It is therefore clear that with the use of the ring sight the deflection allowed is for the movement of the hostile aircraft at right angles to the path of flight of the firer.

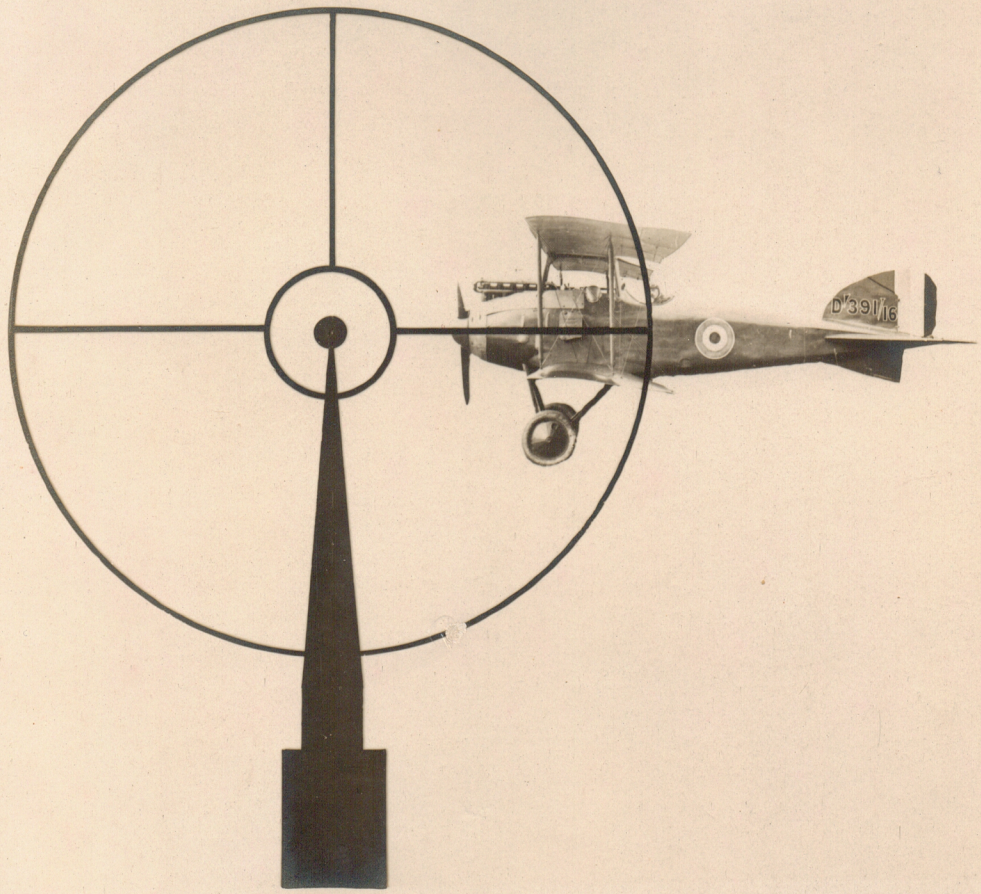
Now, when the hostile aircraft is crossing the path of flight of the firer at an angle other than 90°, part of its movement will be at right angles to and part of it parallel to the path of flight of the firer.

It is therefore obvious that in this case the pilot's seat of the hostile aircraft will have to be allowed to come a certain distance inside the larger ring of the ring sight.

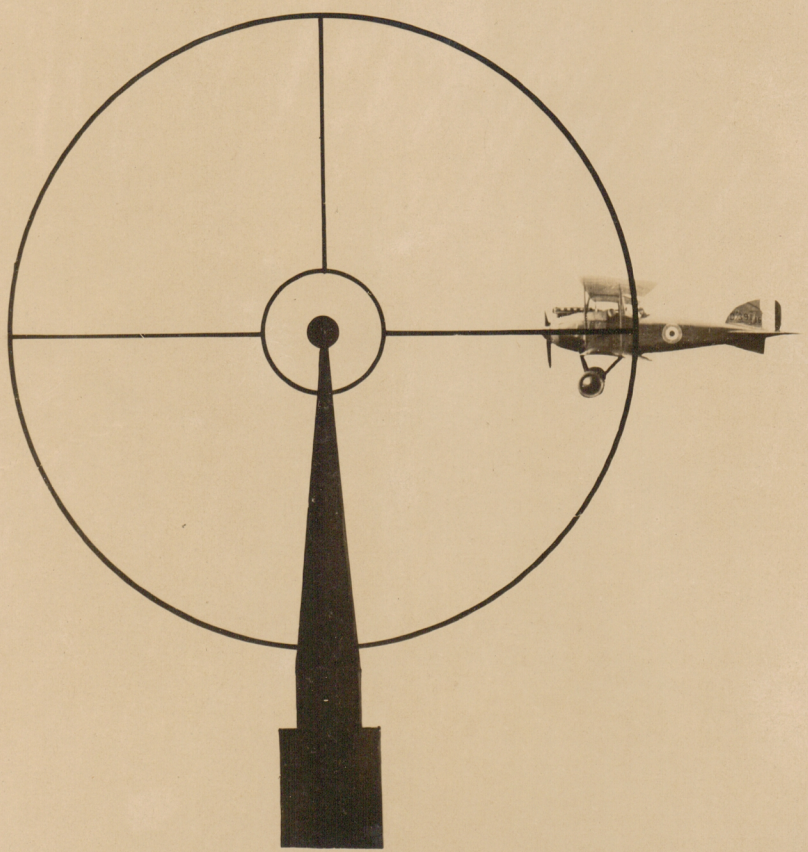
The correct position of the hostile aircraft in the ring sight clearly depends on the angle made by the path of flight of that machine with the path of flight of the firer.

For example, when the path of flight of the hostile aircraft makes an angle of 30° with the path of flight of the firer, the correct position of the pilot's seat of the enemy aeroplane is *half way in.*

When this angle is 45° the correct position is one-third of the way in, and when it is 60° the correct position is one-eighth of the way in.



Hostile Aircraft crossing the path of flight of the firer at right angles at a range of 100 yards.



Hostile Aircraft crossing the path of flight of the firer at right angles at a range of 200 yards.

From these figures it is obvious that as the angle between the path of flight of the enemy aeroplane and the path of flight of the firer diminishes, so does the deflection, and eventually when the hostile aircraft is flying directly towards or away from the firer no deflection is necessary.

In this case, therefore, the enemy machine is placed in the centre of the ring sight.

As has been previously pointed out, when the hostile aircraft is crossing the path of flight of the firer at an angle other than 90°, its correct position in the ring sight is dependent on the magnitude of the angle between their paths of flight.

It is, however, utterly impossible for a Pilot to judge with any degree of certainty the angle made by the path of flight of the hostile aircraft with his own path of flight. Even if this were possible it would, at the same time, be totally impossible for him, particularly in the heat of combat, to call to mind instantly the correct position of the enemy machine in the ring sight corresponding to the particular value of the angle.

As aerial combats are won or lost in seconds and indeed fractions of a second, and as the opportunities of placing a hostile aircraft in its correct position in the ring sight and of opening fire are of such an extremely fleeting nature, it is of the greatest importance that the method adopted for judging the correct position of the enemy machine in the ring sight must essentially be one which can be applied with lightning rapidity, and, indeed, should be one which resolves itself into an instinctive action on the part of the firer. The extreme importance of these principles cannot be too strongly emphasized.

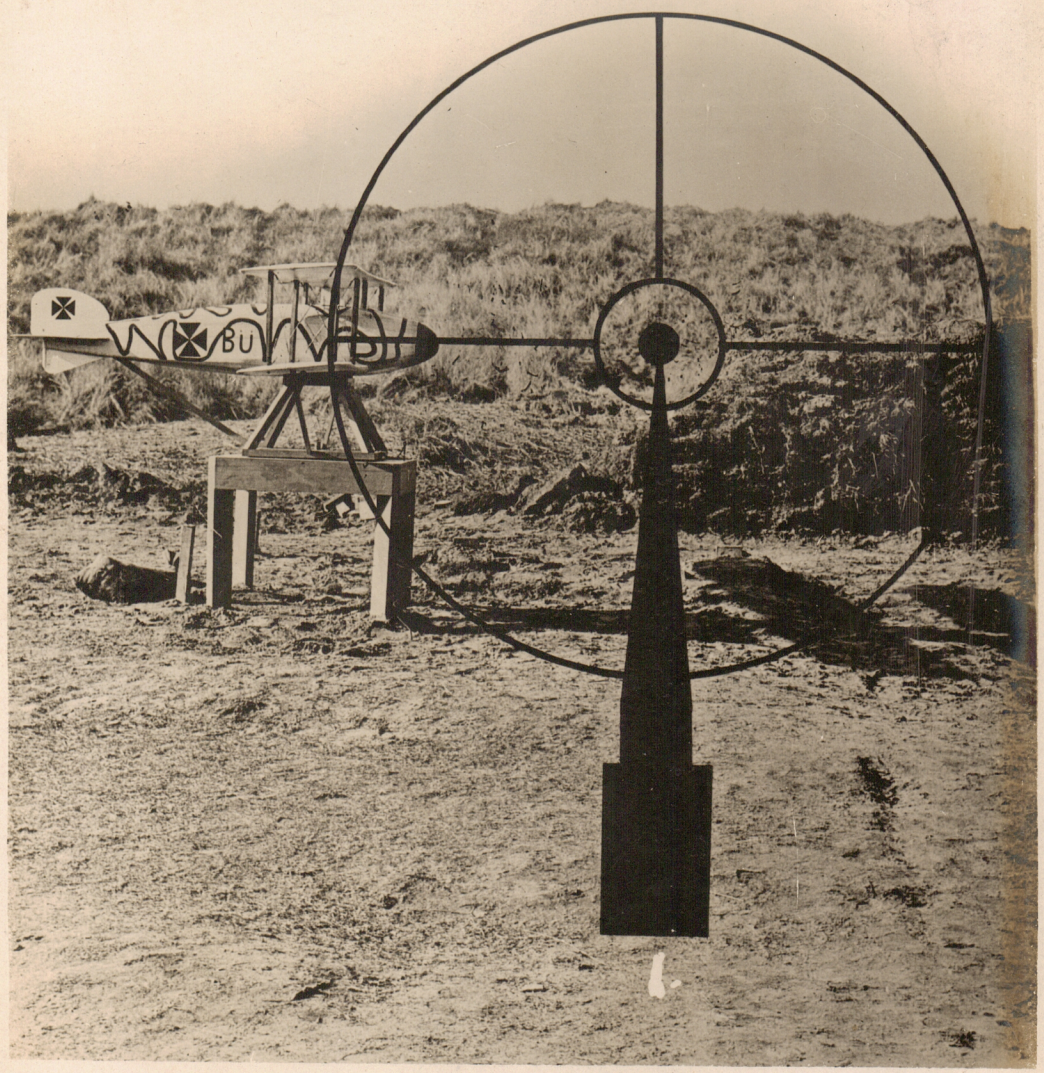
To eliminate the necessity of a firer mentally determining the value of an angle between his own path of flight and that of the hostile aircraft, and of enabling the above principles to be applied, the following method is adopted, viz.:—

When the hostile aircraft is crossing the path of flight of the firer at right angles at any given range the overall dimensions of the fuselage will appear to the firer to be of a given length. Immediately, however, the angle between the path of flight of the firer and that of the enemy aeroplane becomes other than 90 degrees the length of the fuselage at once appears to the firer to shorten. This apparent shortening is known as "fore-shortening," and it is on this fore-shortened aspect of the hostile aircraft that its position in the ring sight is based. The general rule governing this principle is that the more the enemy machine is fore-shortened the nearer it is placed to the centre of the ring sight. It can be quite easily proved that this method is mathematically correct, but for it to be successfully applied in practice means constant and continuous practice on the part of the firer. Skill in the use of the ring sight can only be attained by constant practice.

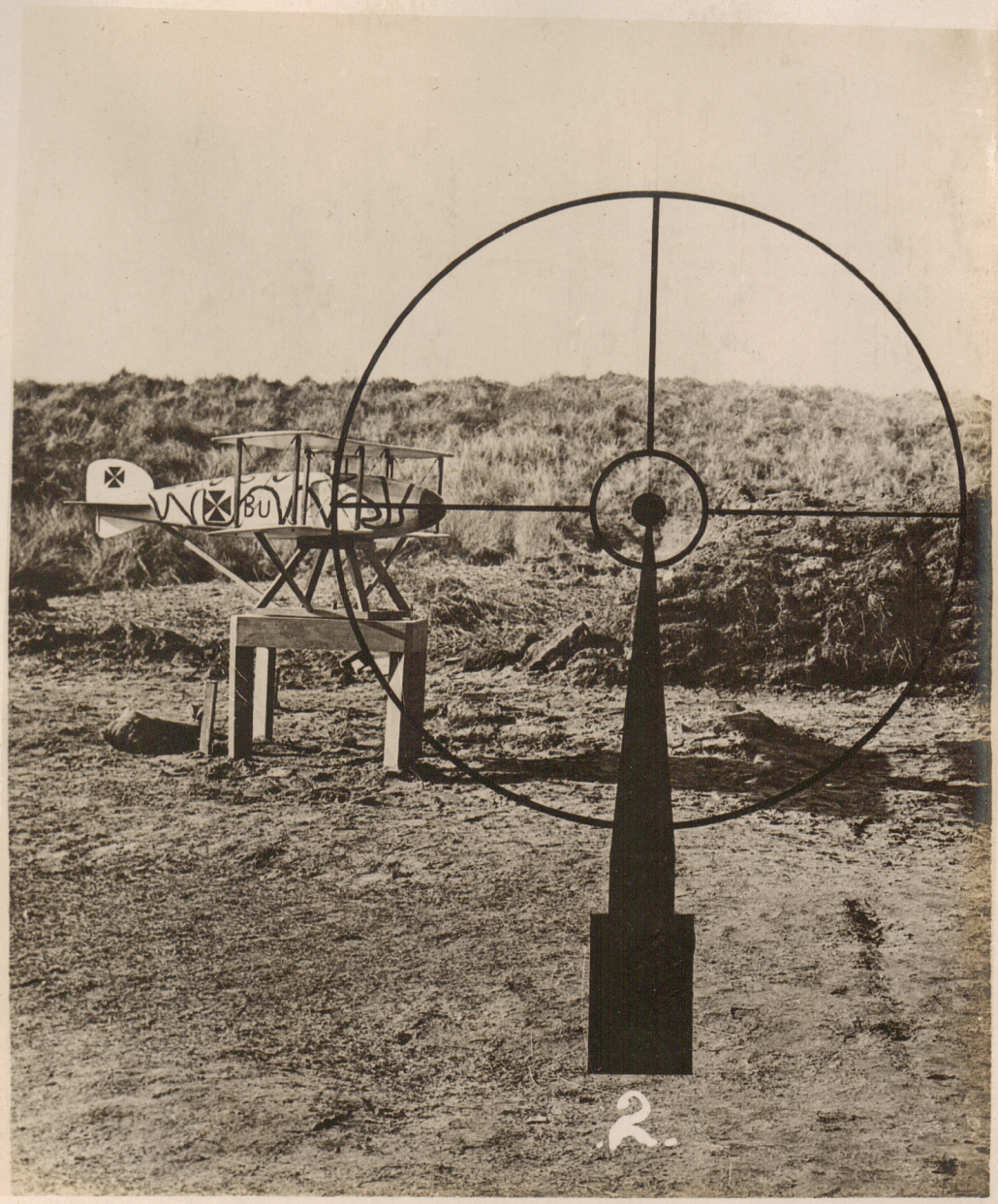
The amount of fore-shortening must not, however, be confused with the actual size of the hostile machine as seen by the firer. This size obviously varies indirectly as the range, or in other words, the greater the range the smaller will the hostile aircraft appear to the firer. It is therefore essential that the firer should be able to instantly and instinctively form an estimate of the range, and from that the fore-shortening on which the position of the hostile aircraft in the ring sight is based.

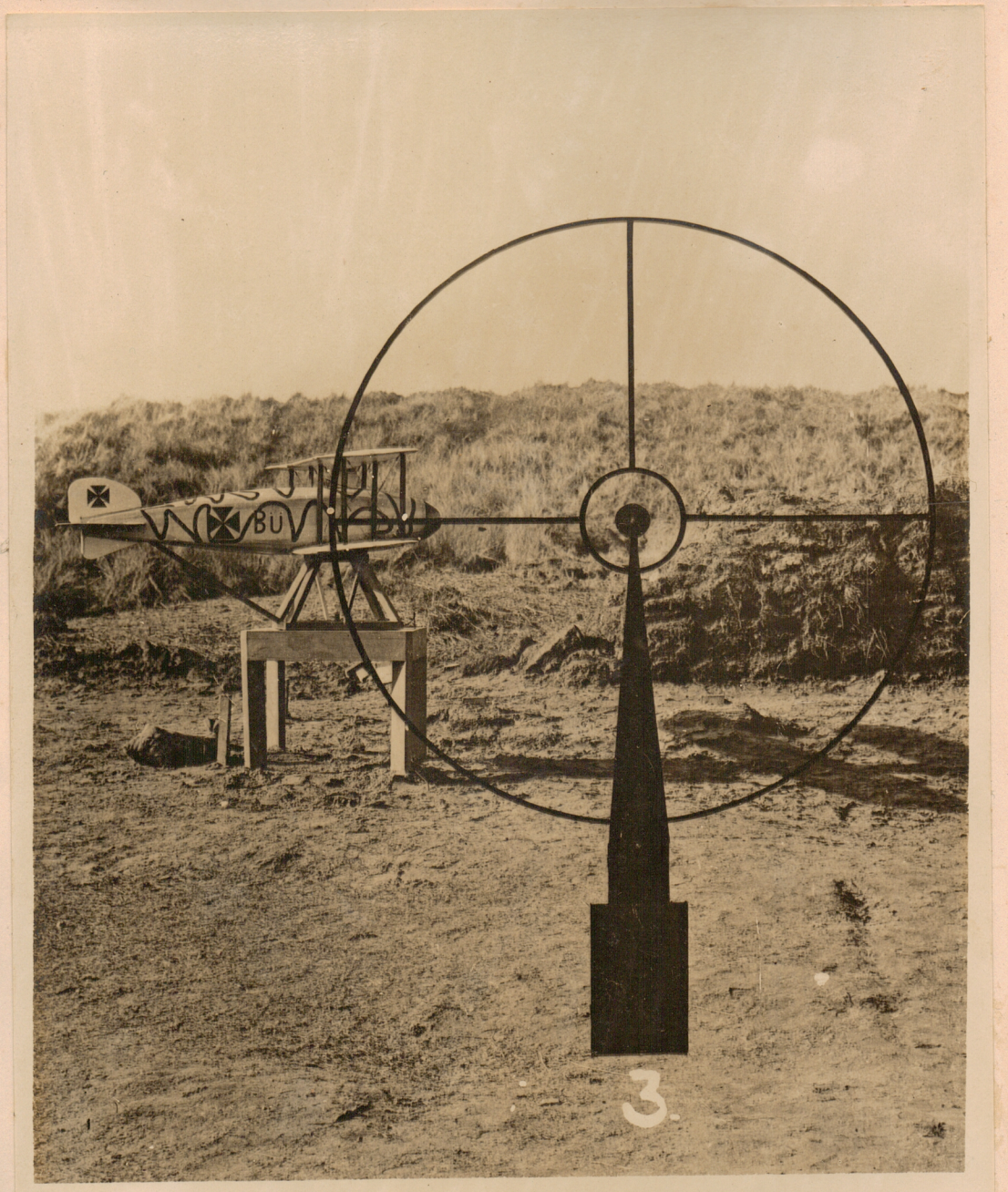
In aerial fighting the target is altering its appearance with bewildering rapidity during the entire fight, so that it is essential that the gunner should have developed by constant and continuous practice the habit of laying his gun correctly for the momentary appearance of the enemy aeroplane and of following the target's movements while he is firing, so that it continually occupies the correct position in the ring sight. Not until this can be done almost as easily and well as a firer can lay a sight directly on a stationary target will he be of much use in aerial fighting. If he has to think much before laying his gun he will—as the favourable opportunities are of such an extremely fleeting nature—fail to get in his burst of fire in time.

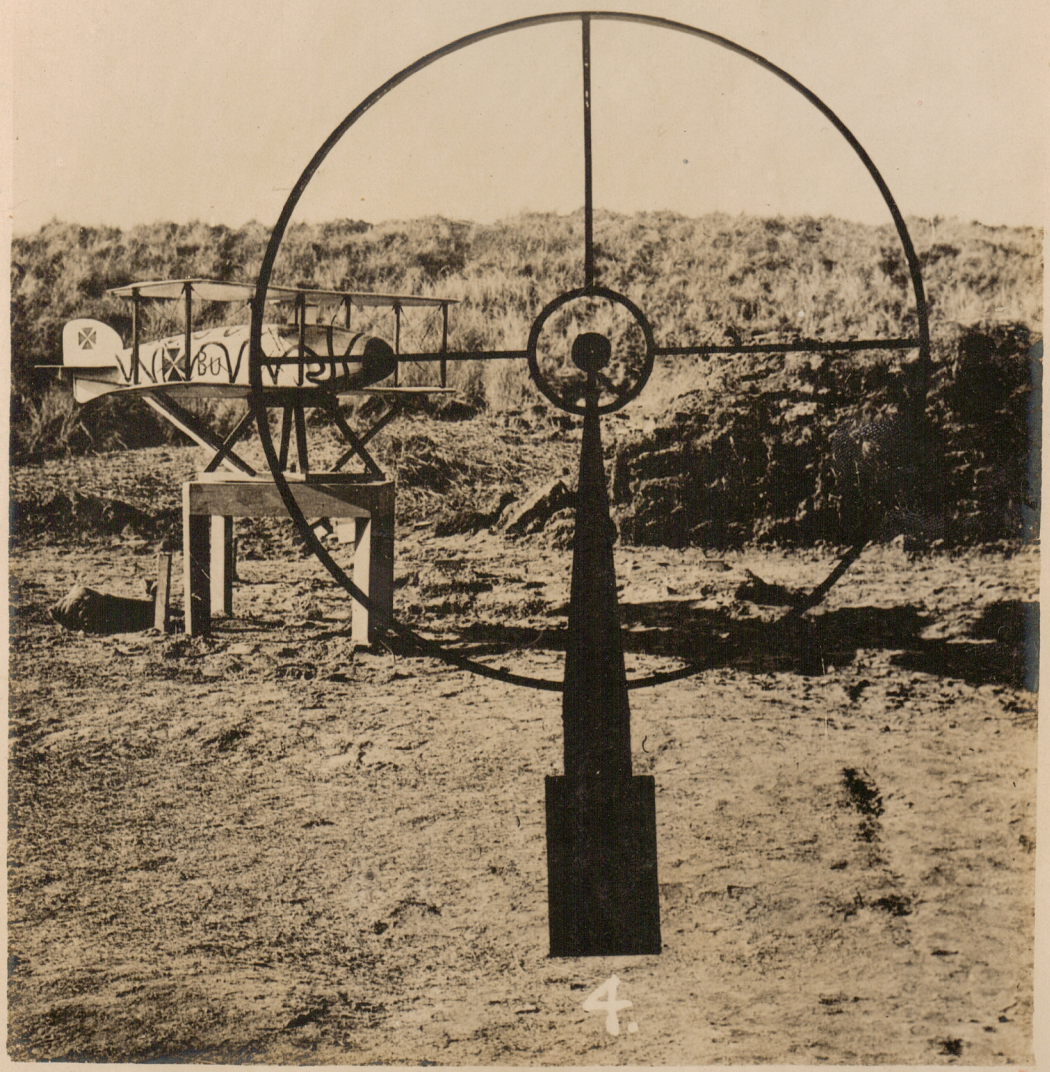
(Continued on page 62).

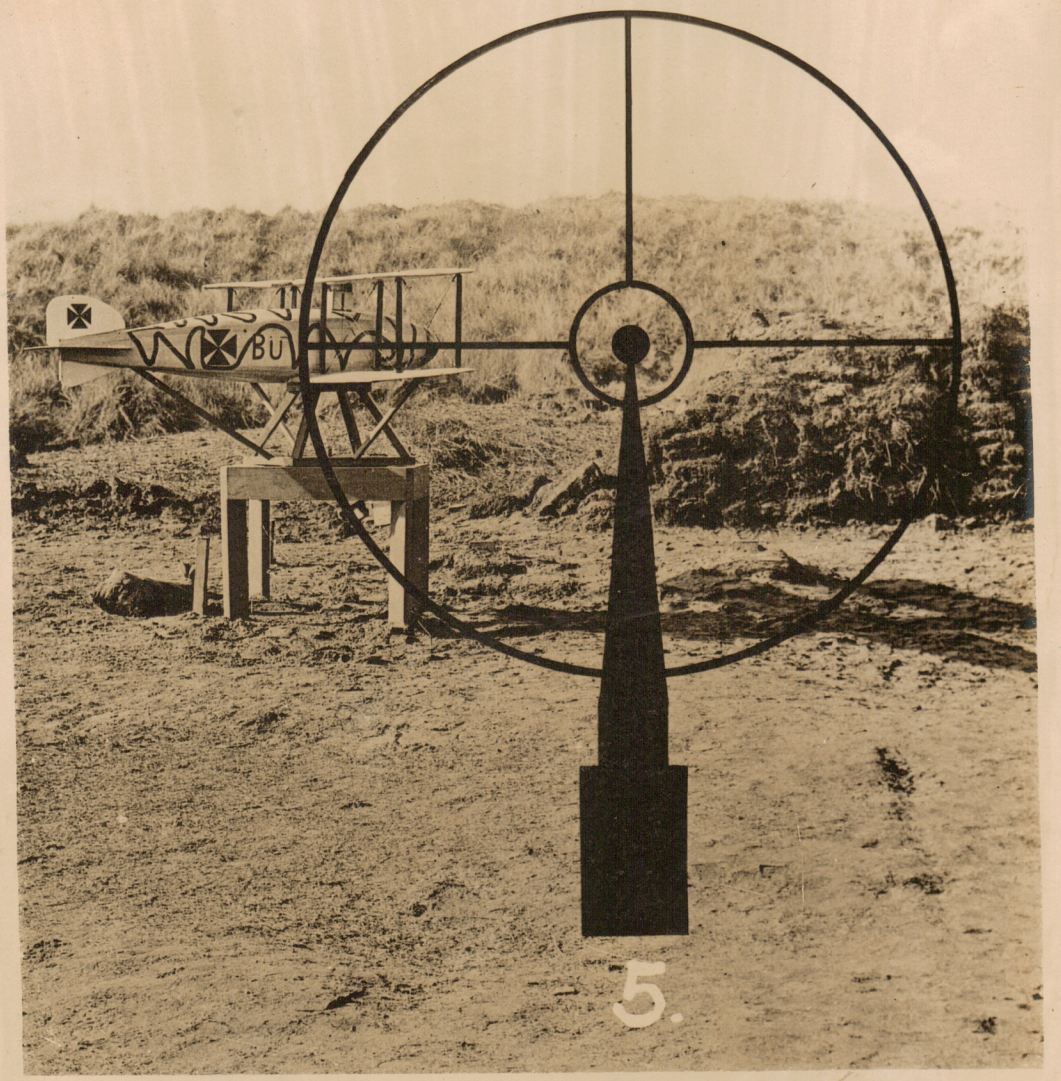


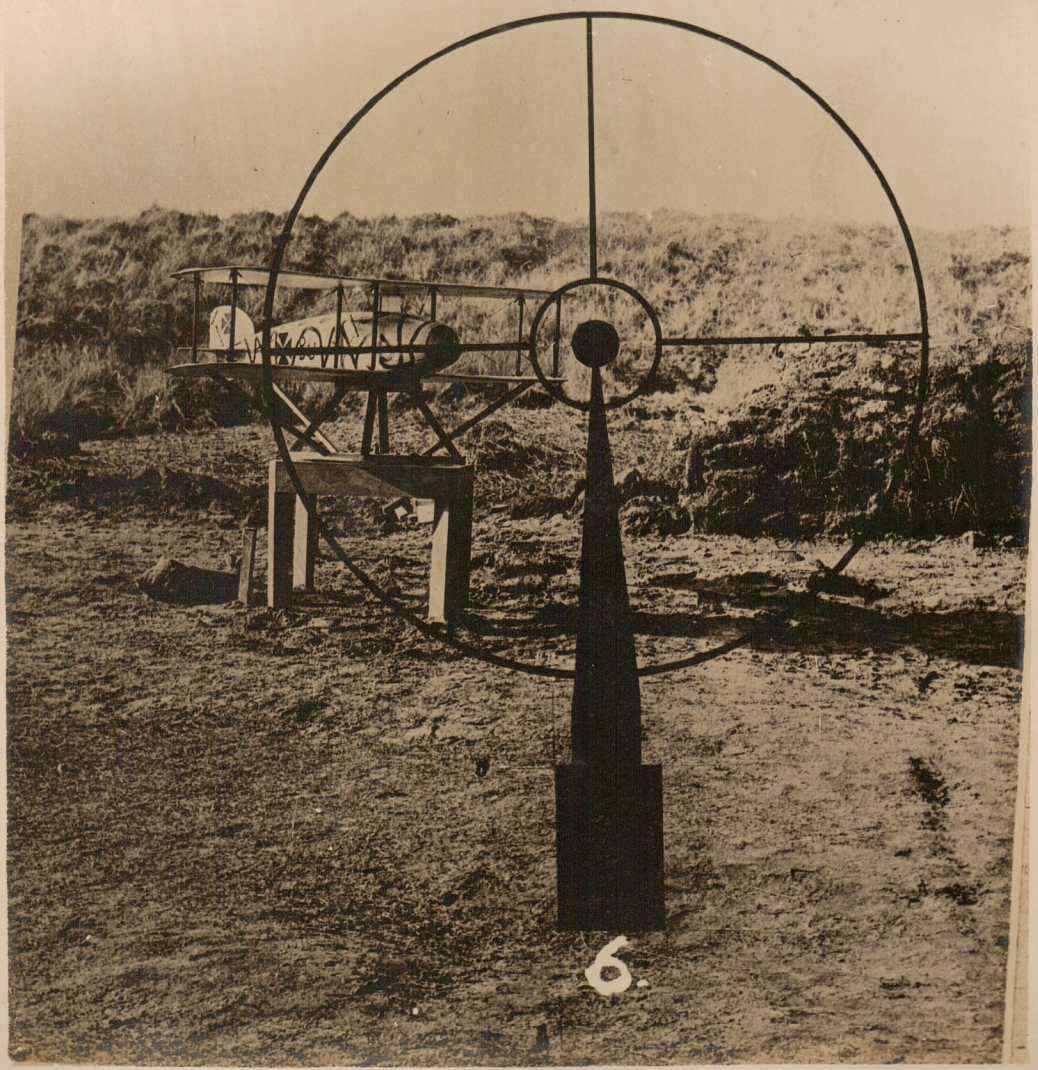
This and the following twelve photographs show the correct position of the Hostile Aircraft in the Ring Sight corresponding to the various "foreshortened" aspects of the Hostile Aircraft both flying in and away.



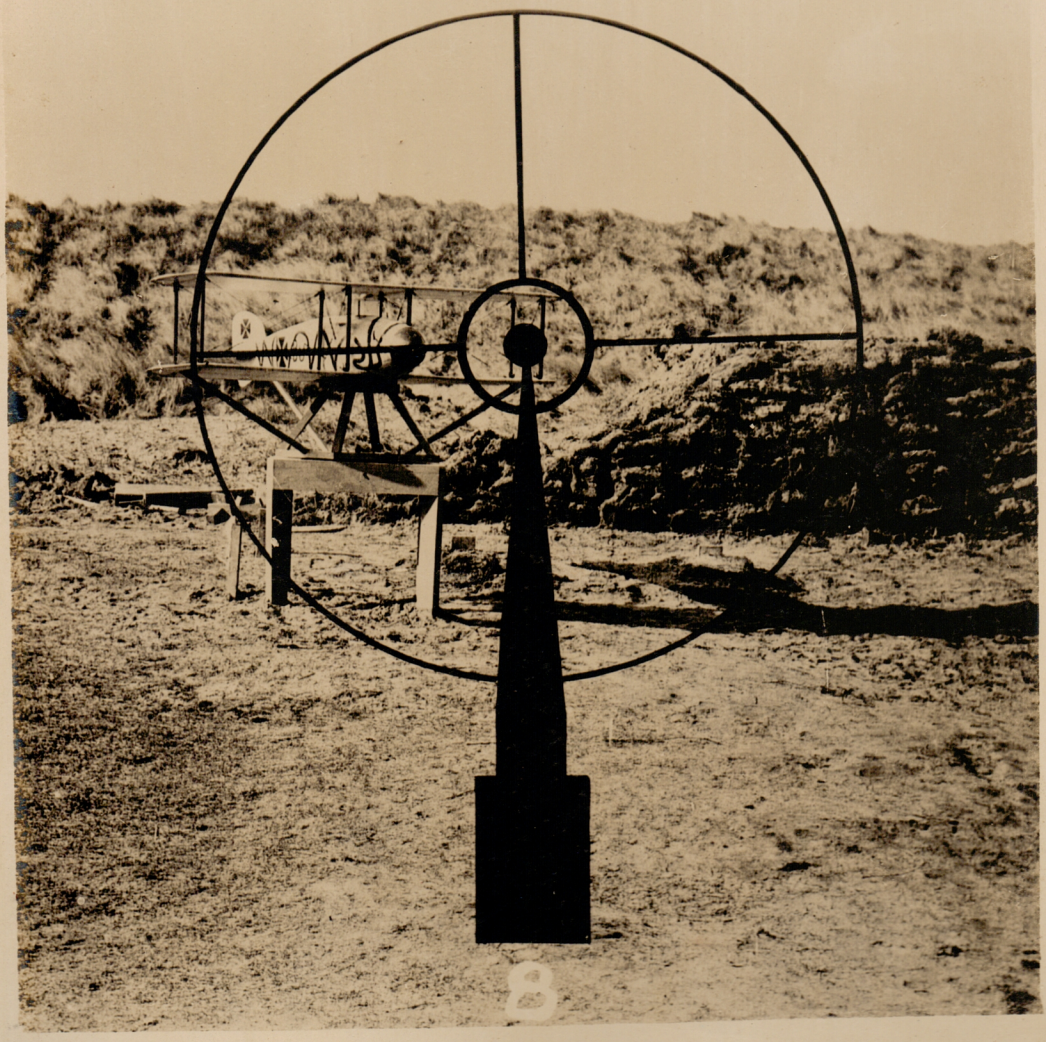

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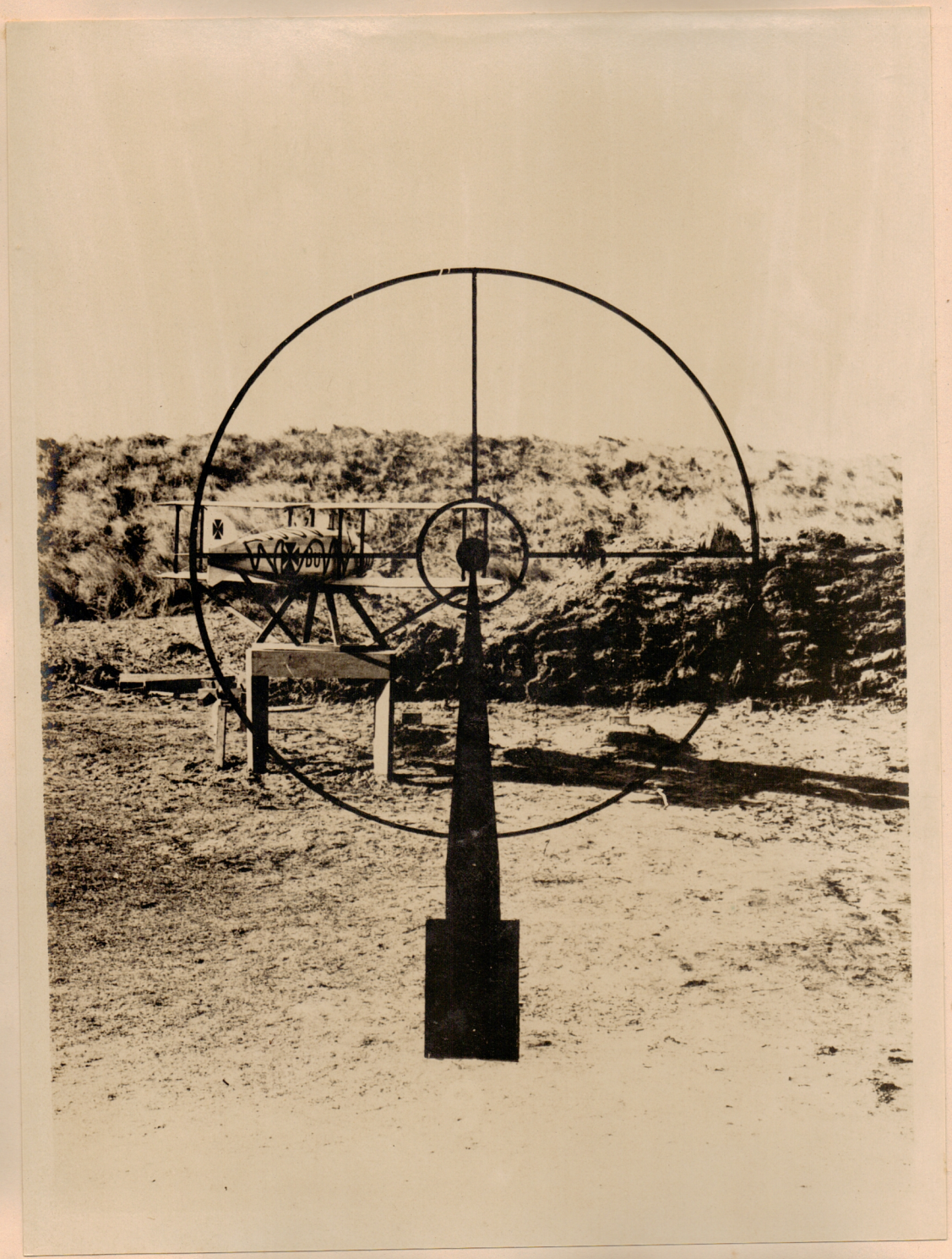

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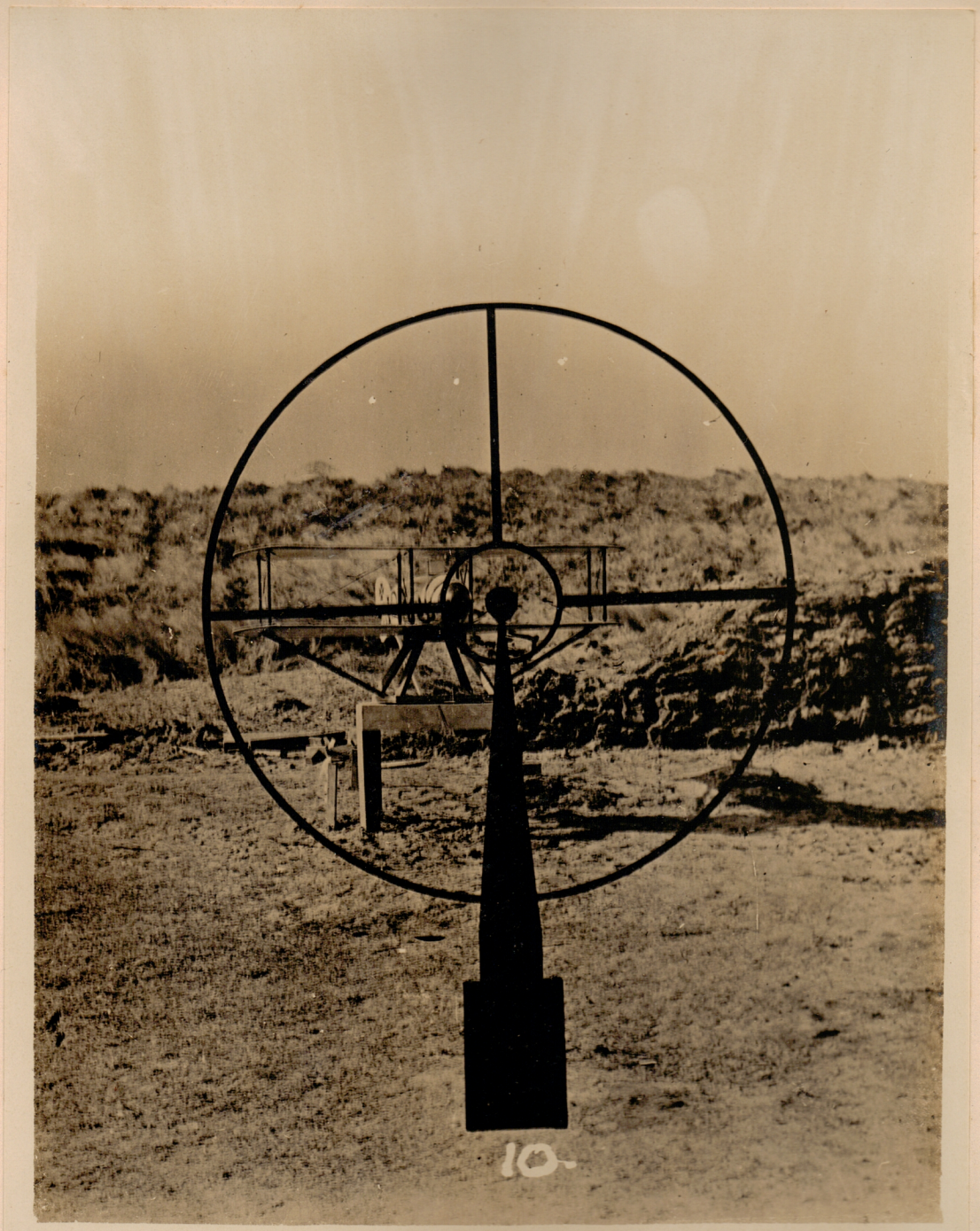

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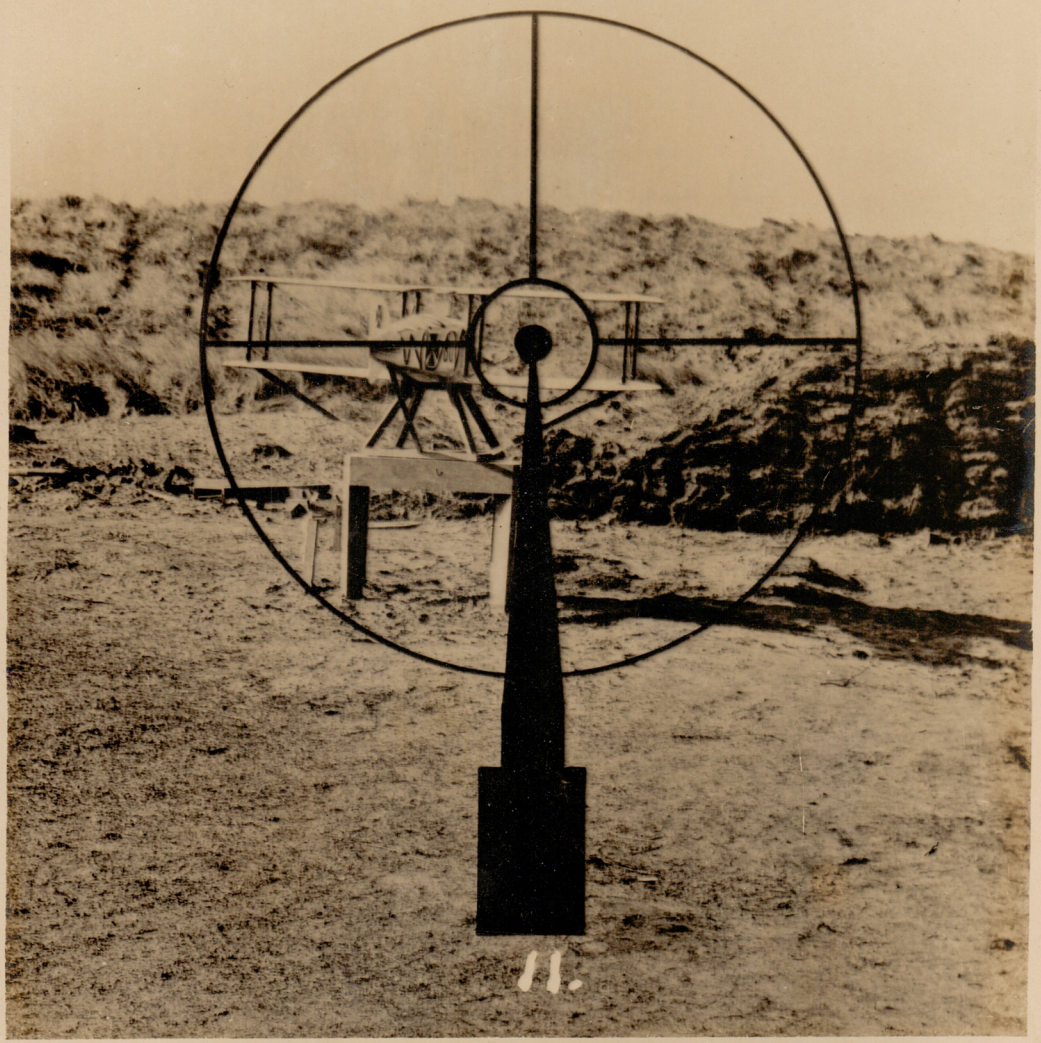

6.

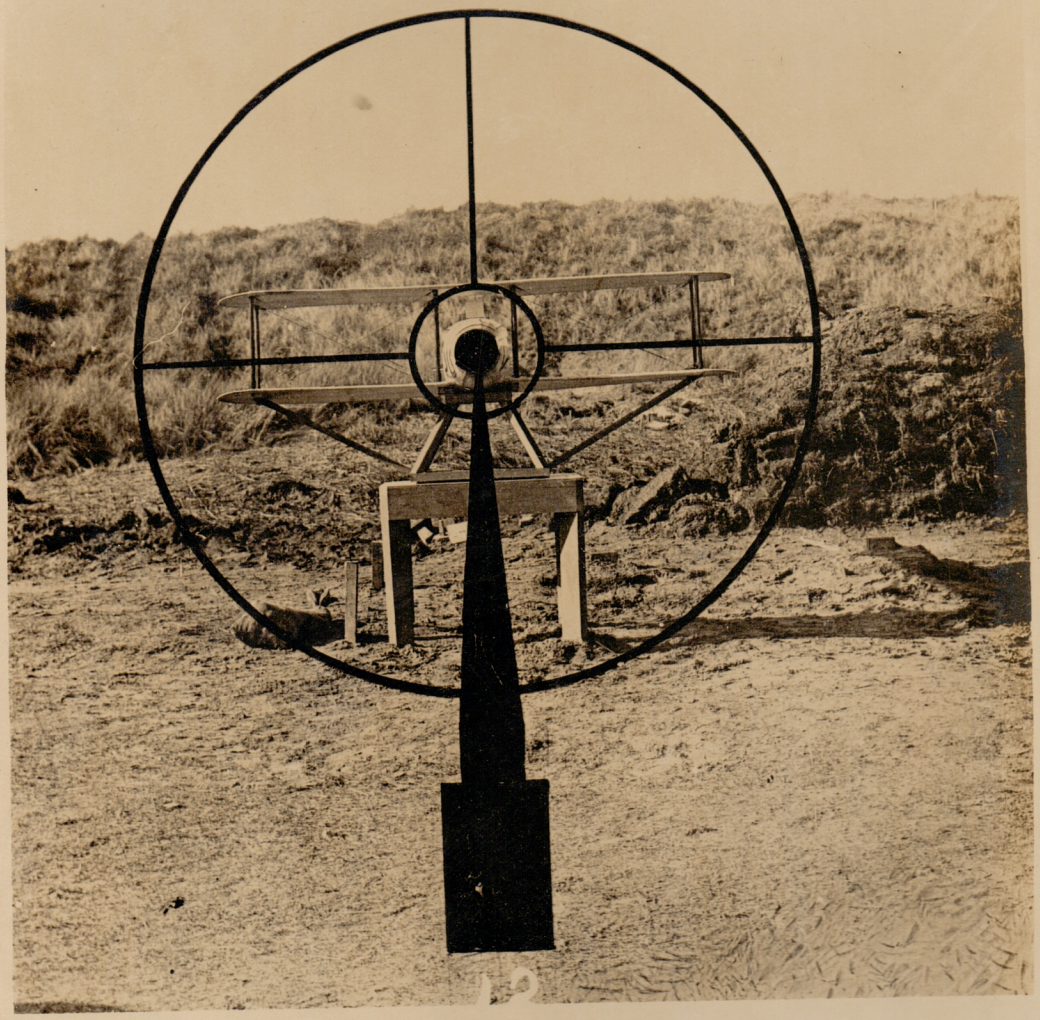

7.

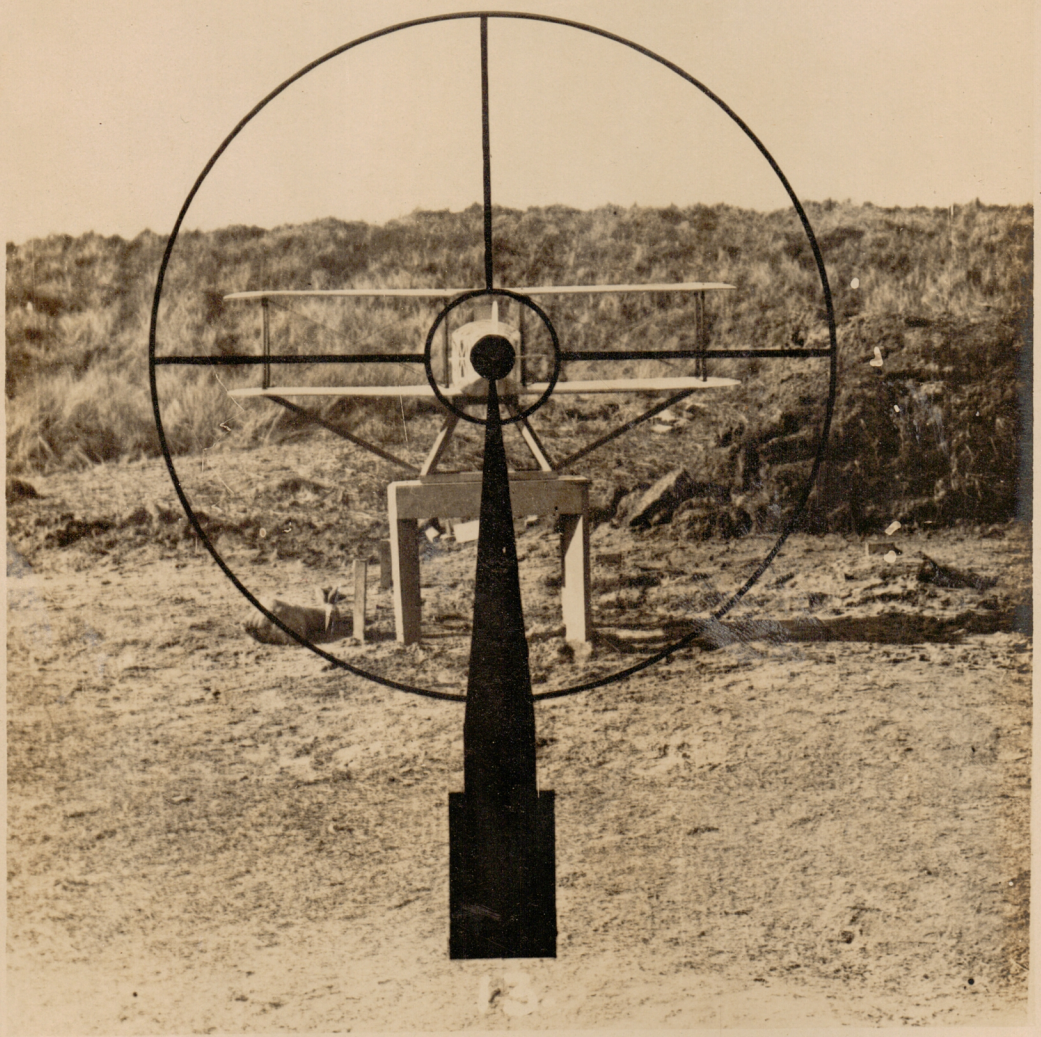


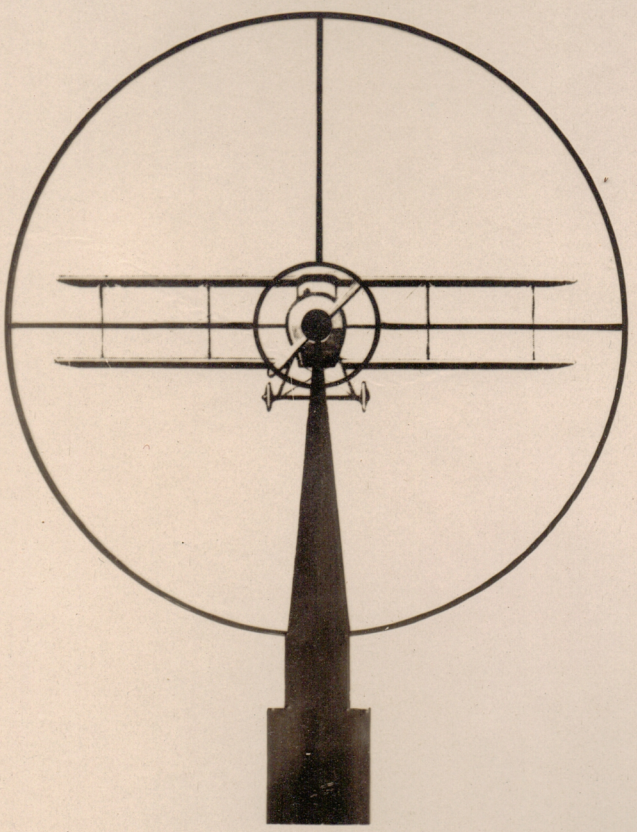



10.

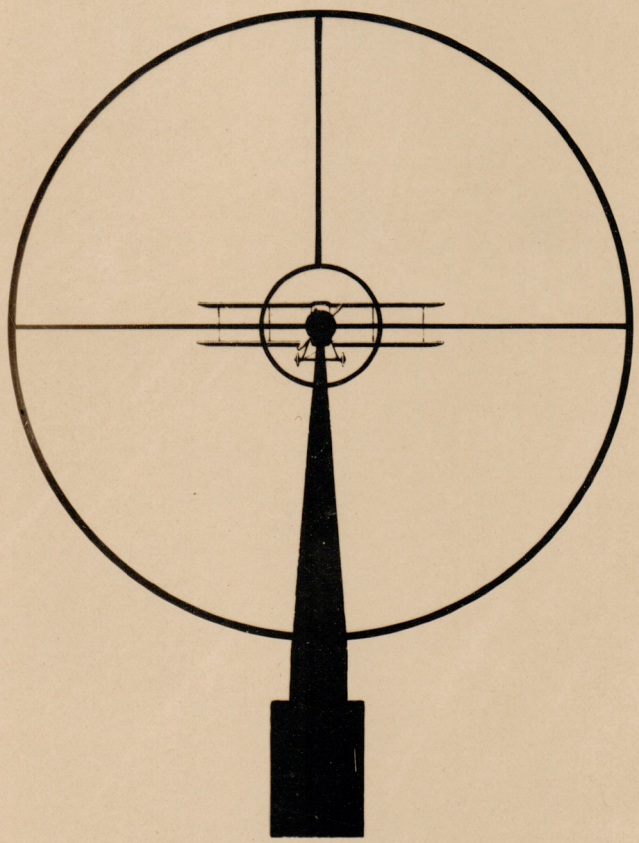

11.







Hostile Aircraft in the "dead-on" position at a range of 100 yds.



Hostile Aircraft in the "dead-on" position at a range of 200 yds.

Again, in actual fighting, the hostile aircraft may be seen from any aspect whatever, and, due to the firer's own speed, may appear to be moving in any direction, irrespective of the direction in which its body may be pointing.

For example, if the enemy aeroplane is approaching from one side, it will appear to be moving rapidly sideways in the direction of the tail of the firer's machine, even though its body may be pointing at an angle approaching 90° to the path of the flight of the firer. Or, again, should it be flying alongside but in the same direction as the gunner, it will appear to be travelling backwards if a slower machine. *The gunner, nevertheless, must learn to make his allowance, in every case, depend upon the direction in which the body of the hostile aircraft is pointing.*

The maximum range at which fire may be advantageously opened is one depending largely on the individual skill and on the relative speed and aspect of the two machines. No hard and fast rule can be laid down for this, but the trend of modern opinion is that the most advantageous range is somewhere in the neighbourhood of 100 yards, and that fire should not, as a general rule, be opened until this range is approximately reached.

It will be noted that, in these notes, the hostile aircraft has, in every case, been assumed to be flying in a straight line and in a horizontal plane at a constant speed of 100 miles per hour.

In actual aerial fighting, however, these ideal conditions practically never exist, as the hostile aircraft will either be climbing or diving, resulting in a diminution of, or increase in, its speed, combined with which it may probably be turning or side-slipping.

It is, therefore, obvious that the deflection obtained by the use of the ring sight will, under these circumstances, be more or less erroneous. At the same time a firer who can use the ring sight with skill will, with constant practice, be able to make approximate allowance for these factors.

Any errors introduced by the approximate results obtained by even comparatively skilful use of the ring sight will tend to be compensated for by the fact that, under the conditions usually met at high altitudes, a practised gunner will spread his shots over a circle of about twelve feet diameter, *i.e.*, six feet radius around the point of aim when the range is 100 yards.

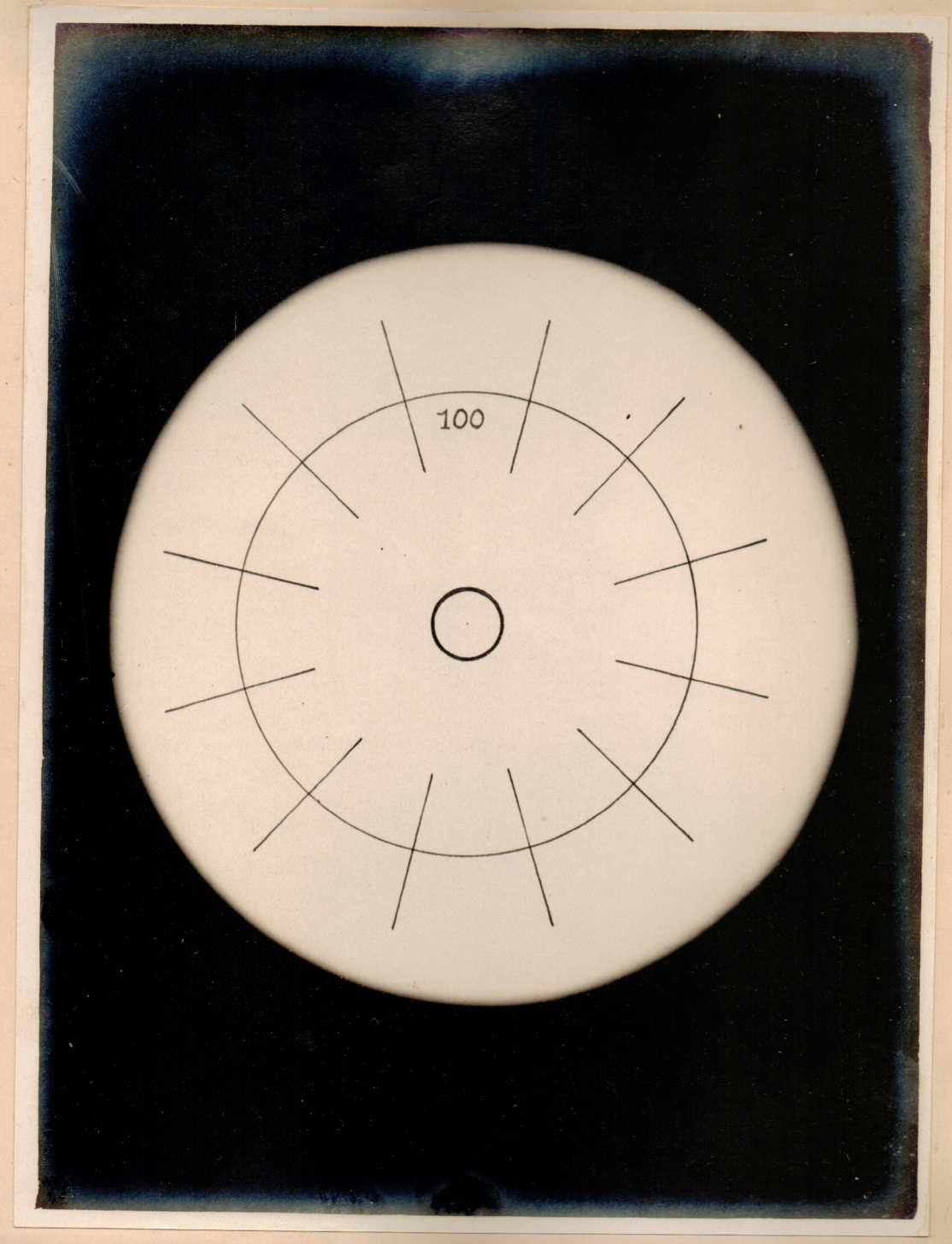
It was at one time thought that direct and visible observation of gun fire would render the most valuable assistance to the aerial gunner, and for this reason tracer ammunition was introduced..

This type of ammunition, however—due to the extreme rapidity with which the relative path of flight of the two machines is changing—affords but little indication of the allowance necessary for relative velocity, and should accordingly be disregarded when the sight can be conveniently used.

At close ranges, however—*i.e.*, under 75 yards—they form a good substitute for a point blank sight, and can often be used with satisfactory results when it is impossible or impracticable to use the sight owing to want of time, or to the difficulty of getting the head into position behind the sight.

The Aldis Optical Sight.

The Aldis Sight is virtually a telescope which does not magnify or diminish, and which, unlike an ordinary telescope, can be used with the eye several inches from the end of the tube. When looking through the tube at a distant object the effect is exactly as though one were looking through a napkin ring, the object appearing the same whether it is seen through the tube or outside it.



Deflection circle of the Aldis sight as seen through the Sight tube.

Within the tube is a glass screen carrying the sighting circle, which is so placed between the lens, that, on looking through the tube at a distant object, the ring is seen with its centre on the spot at which the tube is pointing irrespective of where the eye is placed.

If the eye is moved sideways the ring appears to move with it through the telescope, so that the direction in which the tube points is always towards the centre of the ring.

This tube, when fixed rigidly, therefore constitutes a sight which offers practically no obstruction to the view and which shews instantly the spot at which the gun is pointing, without the necessity of aligning the eye upon a front and back sight.

The sight can, with advantage, be used with both eyes open. One eye then sees the object and the circle through the tube, and the other eye sees the object direct. The effect, after a little practice, is that the object is seen as clearly as though there were no sight at all, but that a circle appears in the sky, the centre of which is the point where the tube is pointing.

As long as the firer can see the circle at all, it is in the correct position for aiming.

The training, therefore, for the use of the Aldis Sight, is exactly the same as laid down for the ring sight, except that those parts of the training relating to the aligning of the eye and the holding of the head at a fixed distance from the ring are no longer necessary.

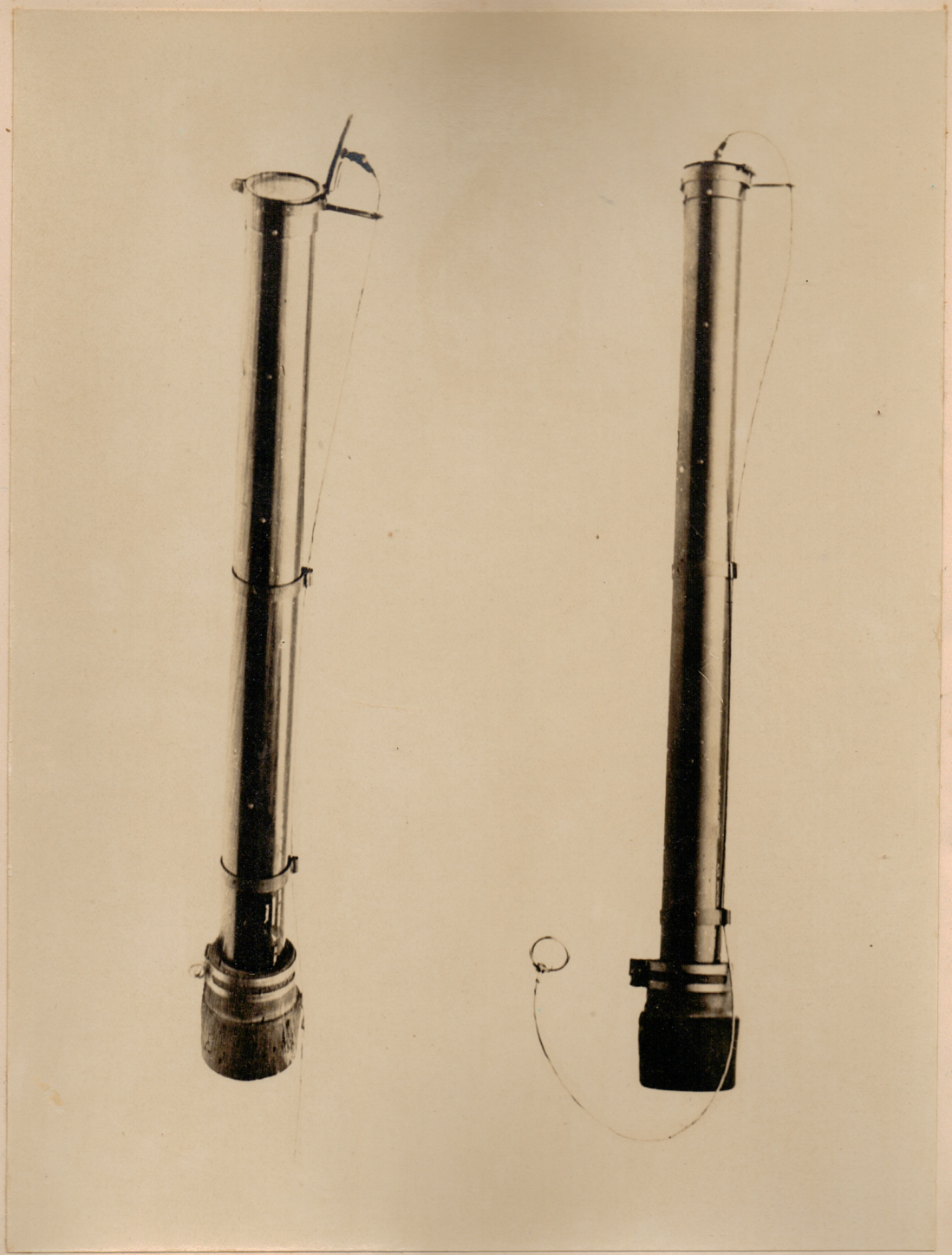
The fixing and the adjustments of the sights will be dealt with under harmonization of sights. This sight is now fitted with a rubber face protector at the eye-piece end and a shutter controlled by a bowden cable at the object end.

This shutter, when closed, covers the object end of the telescope, thus preventing the lens from becoming dimmed by moisture or the exhaust from the engine.

The sight should be removed when not in use by loosening the wing nuts on the clips attaching it to the brackets.

The screw heads on the sight tube indicate the positions occupied by the cemented lens combinations. Care should be taken to avoid gripping the sight tube at or near these parts, as this may cause the balsam to give way.

Care should be taken to see that this sight is drawn down into brackets truly aligned with each other. If it is fixed into brackets that are not true with each other the sight tube will be sprung and the optical properties seriously impaired.



The Aldis Sight fitted with the rubber face protector and shutter, both in the closed and open positions.

Harmonization of Sights.

Introduction.

In Section I. of this book certain precautionary measures and simple tests have been described which, if observed and systematically carried out, will greatly reduce the possibility of an involuntary temporary cessation of fire of the Vicker's gun.

In Section II. will be found a general description of both the Ring and Aldis Sights, and also a more or less brief discussion of the principles underlying the use of these sights.

If any accurate shooting is to be obtained, however, it is obviously necessary that the line of sight should be parallel to or intersect, at a given range, the line of fire.

Harmonization of Sights may therefore be defined as the process of carrying out the necessary adjustments and taking the necessary precautionary measures to ensure that the line of sight is parallel to or intersects, at a given range, the line of fire.

Definitions.

Axis of the Barrel.—Is an imaginary straight line following the centre of the bore from breech to muzzle.

Line of Fire.—Is a line joining the muzzle of the gun and the point of impact.

Line of Sight.—Is a straight line passing through the sights and the point aimed at.

Line of Departure.—Is the direction of the bullet on leaving the muzzle, *i.e.*, the prolongation of the axis of the bore.

At the ranges at which aerial combat takes place, the "line of departure" and the line of fire may be assumed to be co-incident.

It is proposed to deal with the general principles of harmonization as applied to the Ring and Aldis Sights first, and then to deal in detail with the following machines, viz. :—

D.H.4, Bristol Fighter, Camel, and S.E. 5 A.

General Principles.

In all machines in use in the R.A.F. the line of sight is, as a general rule, displaced from the axis of the bore both in the horizontal and vertical planes.

In the case of a machine with one Vicker's gun it is obviously necessary that the sights be so adjustable as to enable the line of sight and line of fire to intersect at a given range.

This range, which is known as the "fighting range," varies in different Squadrons. The trend of modern opinion is, however, that the best fighting range is somewhere in the neighbourhood of 100 yards. No. 56 Squadron, which has been perhaps the most successful Squadron in France, have their guns harmonized for a fighting range of 75 yards.

In the case of a machine fitted with two parallel Vicker's guns the sights should be harmonized so that the line of sight is parallel to the line of fire.

Let us deal first with the case of the machine with one Vicker's gun.

In this case it is necessary to adjust the sight so that the line of sight and the line of fire intersect at a given range.

Let us first deal with the case of the Ring Sight.

The ring sight is used, in the great majority of cases, with the bead as a back sight and the ring as the fore sight.

Both the bead and ring are attached to the barrel casing by means of clamp rings. By loosening the clamp ring screw, both the bead and the ring can be tapped gently to one side or the other. That is to say, both the back sight and fore sight admit of lateral adjustment. The ring cannot be adjusted vertically. The spindle of the bead is, however, screwed and is provided with a locking nut, and can therefore be adjusted in a vertical plane.

It is, therefore, clear that the line of fire is a fixed straight line and the line of sight an adjustable one.

Vertical Adjustment.—Let Fig. 1 represent a diagrammatic elevation of the ring and bead. AB. represents the line of fire and FB 1. the line of sight.

Let the distance AB. represent the fighting range. The line of fire and line of sight should, therefore, intersect at B.

In this diagram, the line FCDB1.— *i.e.*, the line of sight—does not intersect the line of fire at B. The error is BB 1., and is defined as the distance of the line of sight from the line of fire.

To correct this the back sight is lowered to the position C 1. That is to say if the line of sight is found to be below the line of fire, at the range in question, the back-sight is lowered.

This gives us the general rule :—

If the adjustment is made on the back sight and the gun is found to be shooting high, lower the back sight, and if the gun is shooting low raise the back sight.

It can be proved in exactly the same manner that, if the adjustment is made on the fore sight, exactly the opposite holds good, giving us as a general rule :—
If the adjustment is made on the fore sight and the gun is found to be shooting high, raise the foresight, and if the gun is shooting low lower the fore sight.

Lateral Adjustment.

Let Fig. 2 represent a diagrammatic plan of the ring and bead, AB then represents the line of fire, and FB. the line of sight.

Let the distance AB represent the fighting range. The line of fire and the line of sight should intersect at B.

In this diagram the line FCDB1.—*i.e.*, the line of sight—does not intersect the line of fire at B. The error is BB 1.

(See Diagrams on following two pages.)

FIG. I

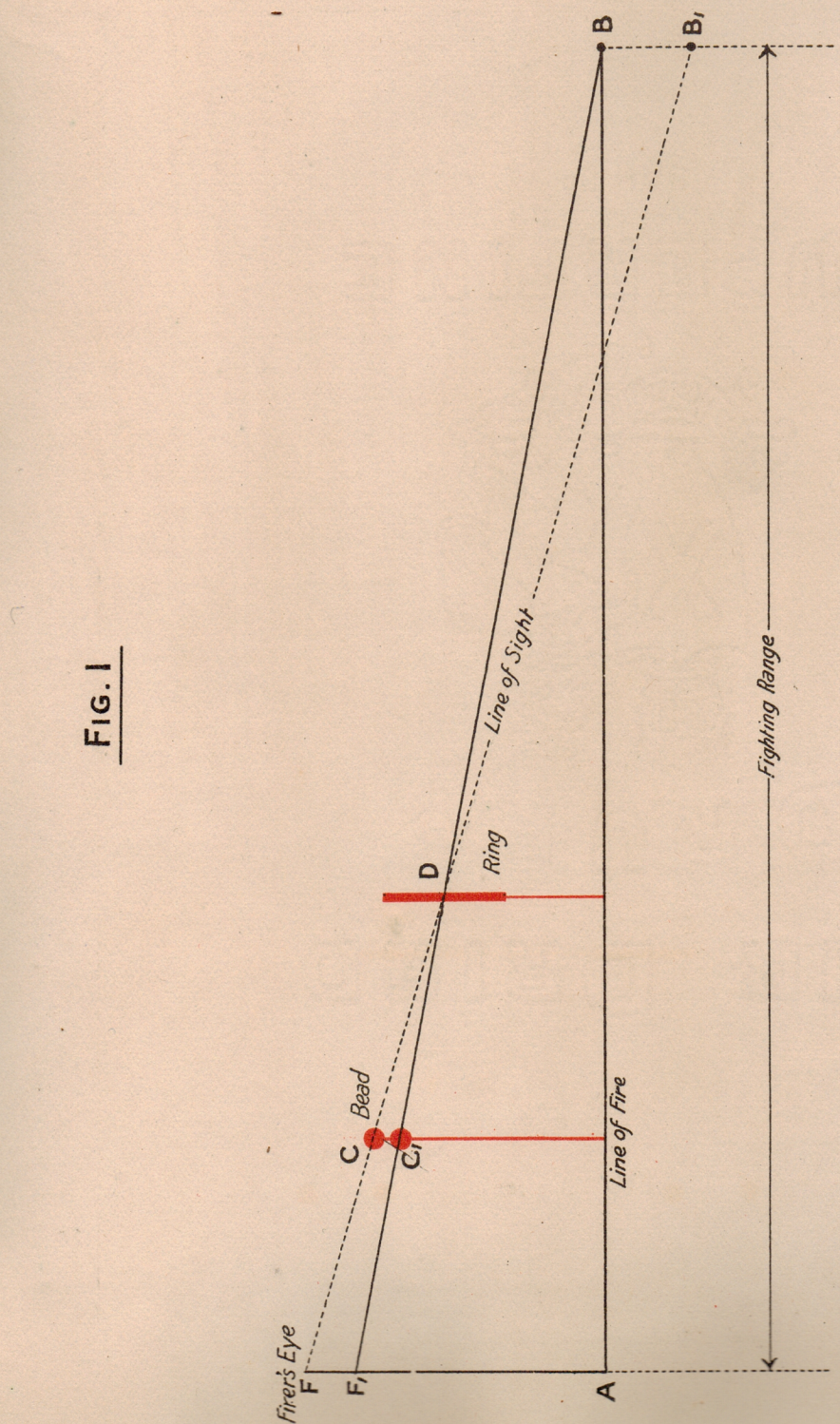
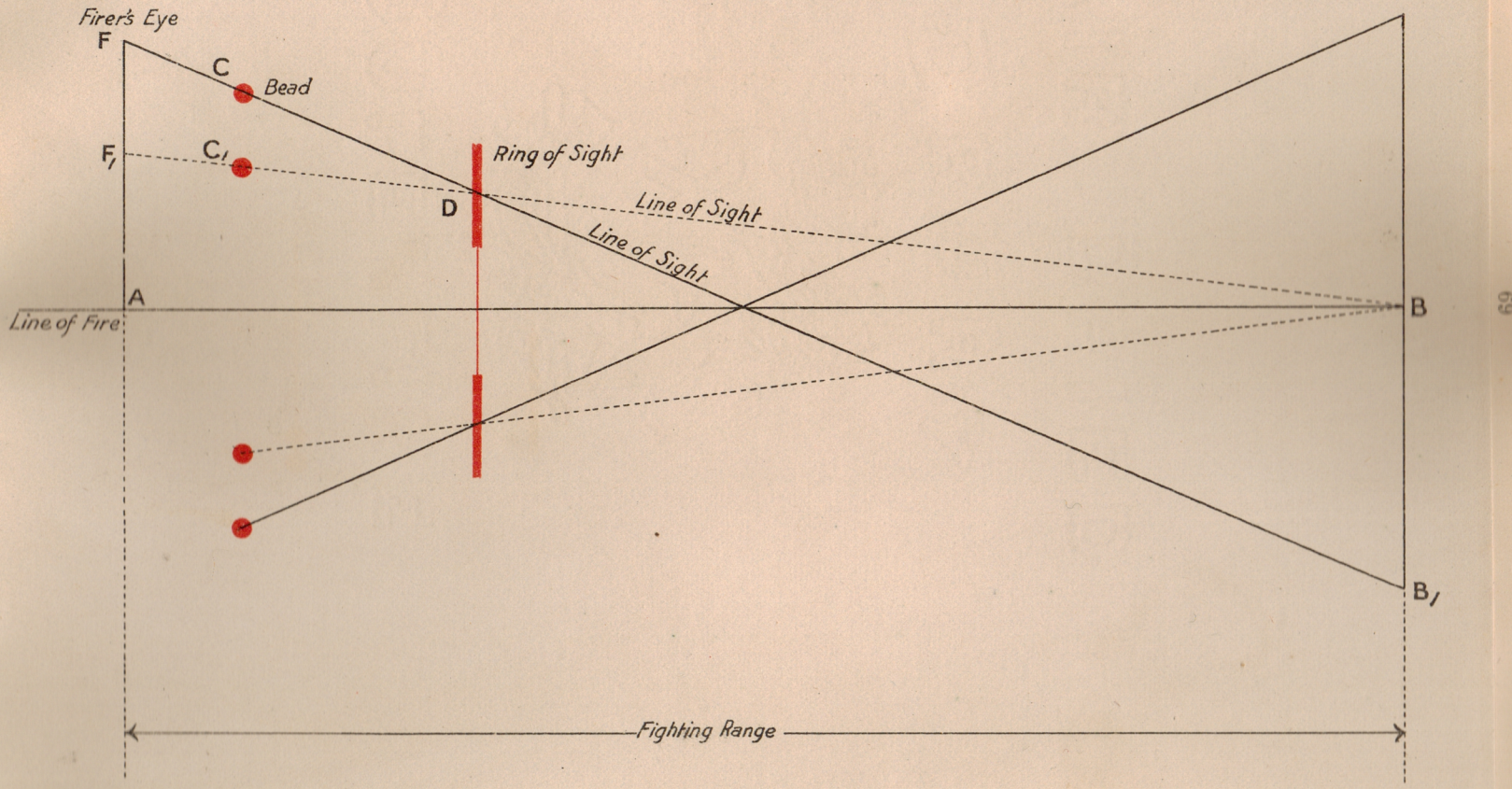

Firer's Eye
F
F1
C
Bead
C1
D
Ring
Line of Sight
B
B1
A
Line of Fire
Fighting Range

FIG. 2


Firer's Eye
F
C
Bead
F/
C/
Ring of Sight
D
Line of Sight
Line of Sight
A
Line of Fire
B
B/
Fighting Range

To correct this the back sight is moved to the position C 1. That is to say, if the line of sight is found to be to the right of the line of fire, the back sight is moved to the right.

This gives us the general rule.—*If the adjustment is made on the back sight and the gun is found to be shooting to the left, the back sight is moved to the right, and if the gun is shooting to the right the bead back sight is moved to the left.*

It can be proved in exactly the same manner that, if the adjustment is made on the fore sight, exactly the opposite holds good, giving us as a general rule :– *If the adjustment is made on the fore sight and the gun is found to be shooting to the left, the fore sight is moved to the left, and if the gun is shooting to the right the fore sight is moved to the right.*

To ensure that any adjustments in either the back sight or the fore sight are maintained, the lock nuts provided for this purpose must be carefully tightened up after harmonization has been completed.

To carry out Harmonization on the Range.

Put the machine approximately in flying position at the fighting range from the target. Glance through the battle sights and adjust the position of the fuselage to ensure that if a short burst is fired the shots will hit the target. Start up the engine and fire a short burst of say ten rounds into the target. Ascertain the point of mean impact—*i.e.*, the centre of the group—and mark this visibly on the target.

Look carefully along the line of sight and if the gun is found to be shooting high or low or to one side, adjust the line of sight in the manner previously described.

Repeat this process until the line of fire and line of sight intersect at the fighting range. *Lock up all lock nuts and re-check.*

The Sights must be carefully harmonized in this manner prior to each flight over the lines.

Harmonization of Aldis Sight on S.E.5A.

The procedure to be adopted in harmonizing this sight is exactly the same as previously described.

The photographs on the two following pages show the front and rear brackets for the sight as fitted to the S.E.5A.

It will be seen from these photographs that the rear bracket—which also forms the rear fixing for the Foster mounting—is the one on which the lateral adjustment is made.

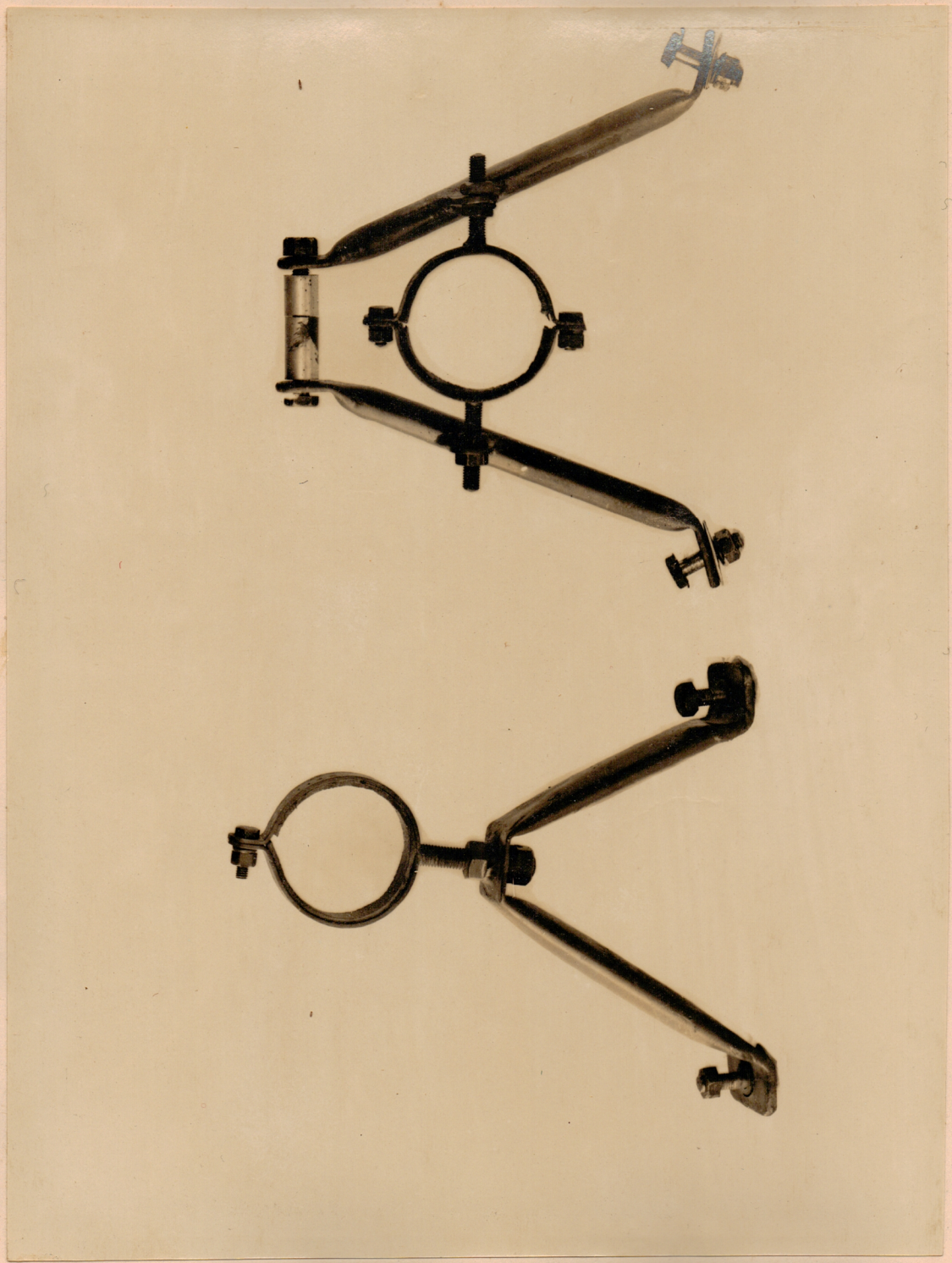
It is therefore clear that, in this case, if the gun is found to be firing to the left the clip on the bracket is adjusted to move to the right, and vice versa.

It will also be seen from these photographs that the vertical adjustment is made on the front bracket.

In this case, therefore, if the gun is found to be firing high, the clip on the bracket is adjusted to move up, and if firing low, to move down.

The second photograph shews the Aldis Sight actually in position on the machine. The screw heads on the sight tube indicate the positions occupied by the cemented lens combinations. Care should be taken to avoid gripping the sight tube at or near these points, as this may cause the balsam to give way.

Care should also be taken to see that the sight is drawn down into brackets truly aligned with each other. If it is fixed into brackets that are not true with each other the sight tube will be sprung and the optical properties seriously impaired.



Front and rear Aldis Sight brackets as fitted to the S.E. 5A.



Aldis Sight in position on the S.E. 5A.

Harmonization of Aldis Sight on D.H4.

The procedure to be adopted in the harmonization of the Aldis Sight on this machine is exactly similar to that previously described.

The photographs on the two following pages shew the front and rear brackets for the sight as fitted to the D.H4.

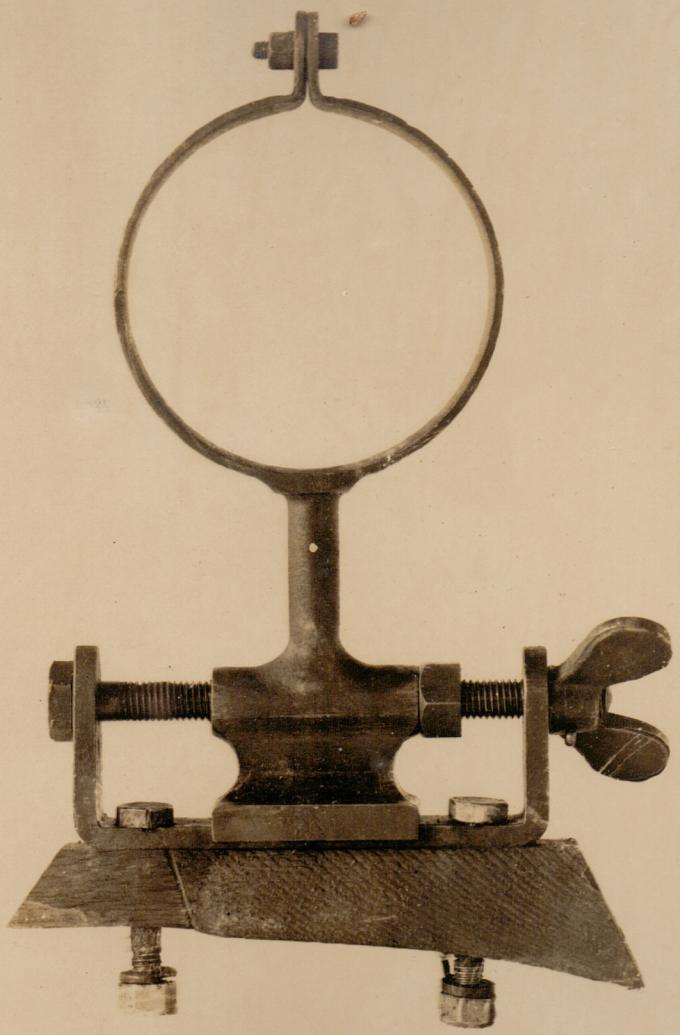
It will be seen from these photographs that the rear bracket is the one on which lateral adjustment is made, and that on the front bracket vertical adjustment is provided for.

It is, therefore, clear that if the gun is found to be shooting to the left, the clip on the rear bracket is adjusted to move to the right, and vice versa.

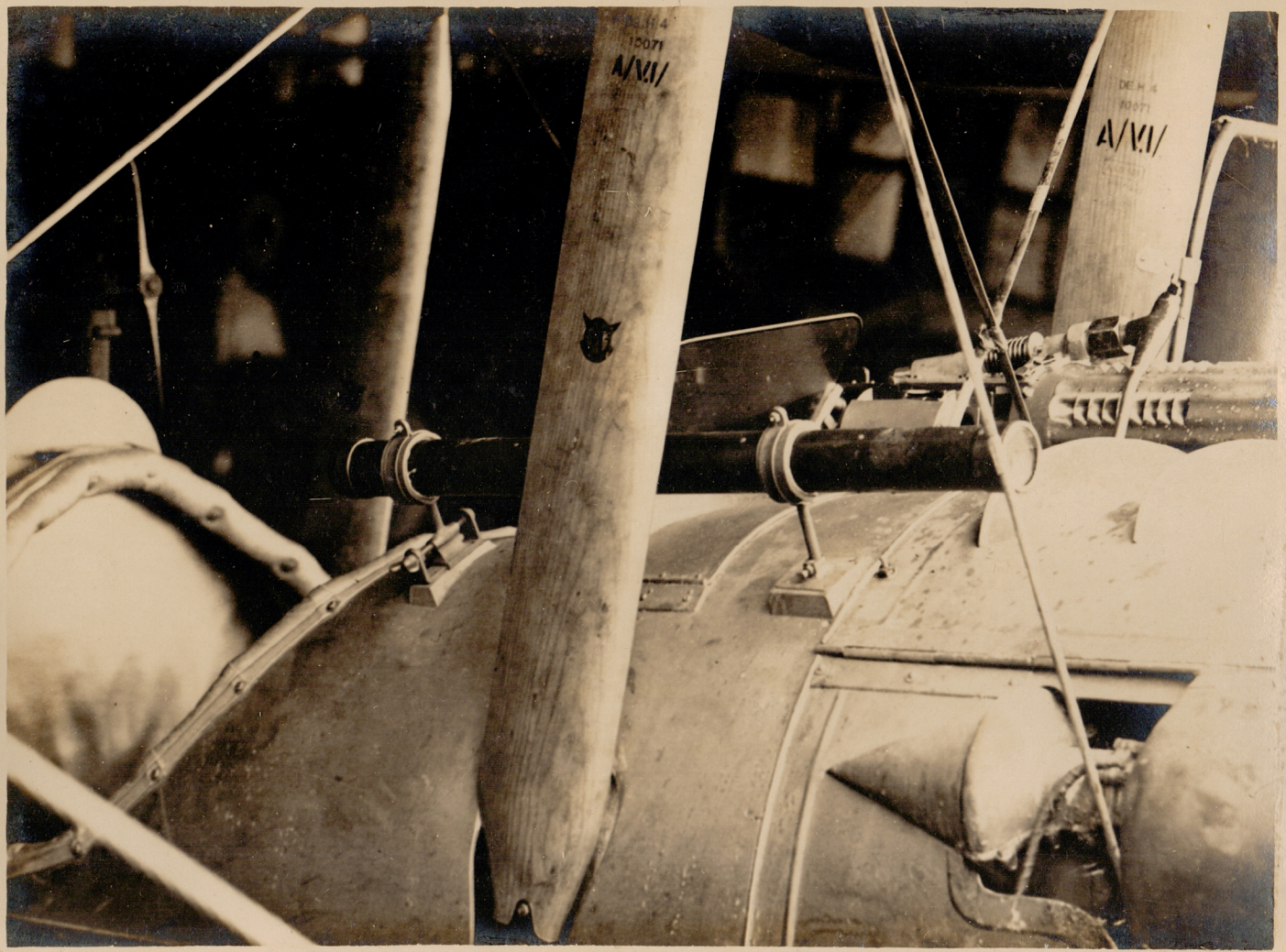
Also, if the gun is found to be shooting high the clip on the front bracket is adjusted to move up, and if shooting low to move down.

The screw heads on the sight tube indicate the positions occupied by the cemented lens combinations. Care should be taken to avoid gripping the sight tube at or near these points as this may cause the balsam to give way.

Care should also be taken to see that the sight is drawn down into brackets truly aligned with each other. If it is fixed into brackets that are not true with each other the sight tube will be sprung and the optical properties seriously impaired.



Rear Aldis Sight bracket as fitted to the D H4.



Aldis Sight in position on the D. H4.

Harmonization of the Aldis Sight on the Bristol Fighter.

The procedure to be adopted in the harmonization of the Aldis Sight on this machine is exactly similar to that previously described.

The photographs on the two following pages shew the front and rear brackets of the Aldis Sight as fitted to the Bristol Fighter.

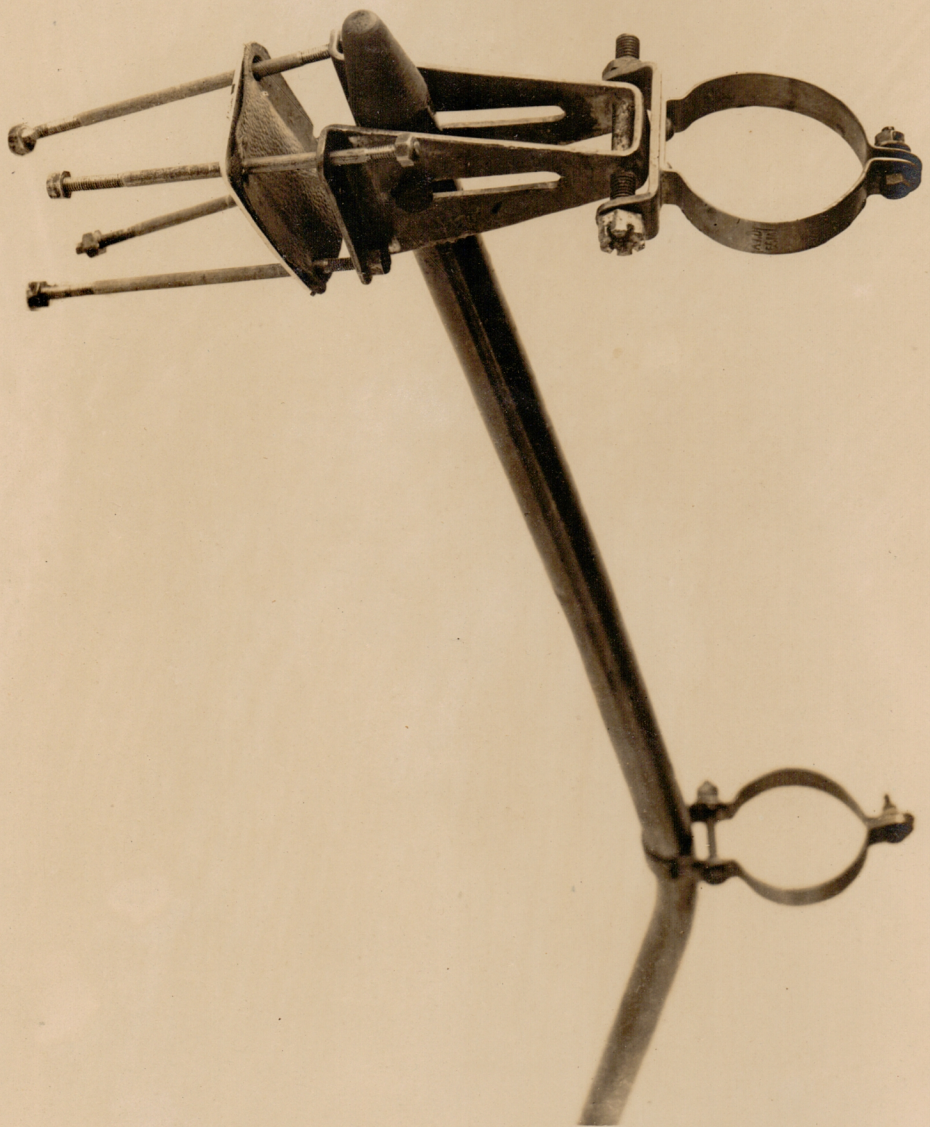
It will be seen from these photographs that the rear bracket is the one on which both lateral and vertical adjustment is made.

It is therefore clear that if the gun is found to be shooting to the left, the clip on the rear bracket is adjusted to move to the right, and if shooting right to move to the left.

Also, if the gun is found to be shooting high the clip on the rear bracket is adjusted to move down, and if shooting low to move up.

The screw heads on the sight tube indicate the positions occupied by the cemented lens combinations. Care should be taken to avoid gripping the sight tube at or near these points, as this may cause the balsam to give way.

Care should also be taken to see that the sight is drawn down into brackets truly aligned with each other. If it is fixed into brackets that are not true with each other, the sight tubes will be sprung and the optical properties seriously impaired.



Aldis Sight brackets as fitted to the Bristol Fighter.



Aldis Sight in position on the Bristol Fighter.

Harmonization of the Aldis Sight on the Sopwith Camel.

The procedure to be adopted in the harmonization of the Aldis Sight on this machine is exactly similar to that previously described.

The photographs on the two following pages shew the front and rear brackets for the Aldis Sight as fitted to the Camel. It will be seen that these brackets are exactly similar.

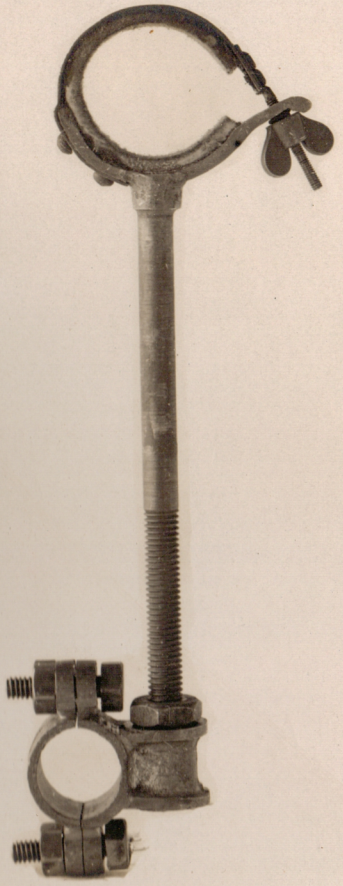
These brackets are fitted to cross tubes in the fuselage. As the front bracket is difficult to get at for adjustment purposes, all adjustments for harmonization are made on the rear bracket.

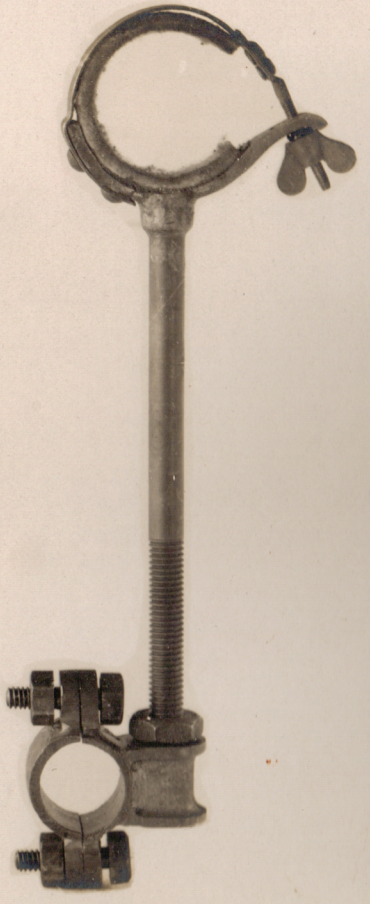
It is therefore clear that if the gun is found to be shooting high, the clip on the rear bracket is adjusted to move down, and if shooting low, to move up.

Also, if the gun is shooting to the left, the clip on the rear bracket, or rather the whole bracket, is moved to the right, and if shooting to the right is moved to the left.

The screw heads on the sight tube indicate the positions occupied by the cemented lens combinations. Care should be taken to avoid gripping the sight tube at or near these points, as this may cause the balsam to give way.

Care should also be taken to see that the sight is drawn down into brackets truly aligned with each other. If it is fixed into brackets that are not true with each other the sight tube will be sprung and the optical properties seriously impaired.





Aldis Sight Brackets as fitted to the Sopwith Camel.



Aldis Sight in position on the Sopwith Camel.

Loading Handles.

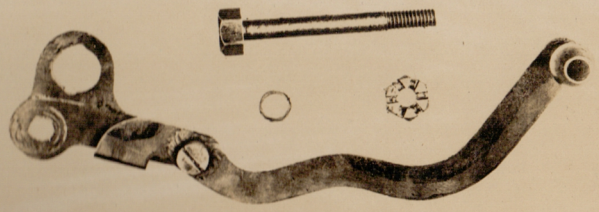
The photographs on the opposite page show a few of the loading handles in use in the R.A.F.

The top photograph shows the Cox's D Type loading handle as fitted to the D H 4.

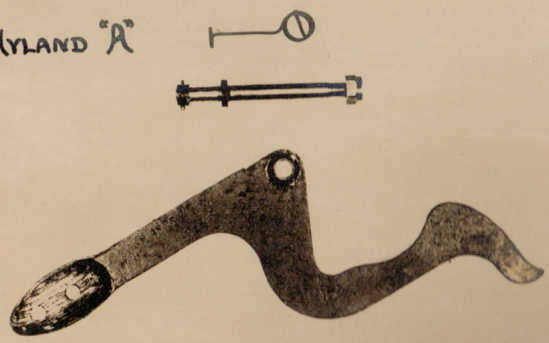
The second photograph shows the Hyland Type A loading handle as fitted to the Sopwith Camel.

The third photograph shows the Hyland Type B as fitted to the Bristol Fighter, and the fourth photograph shows the Hyland Type E as fitted to the S E 5 A.

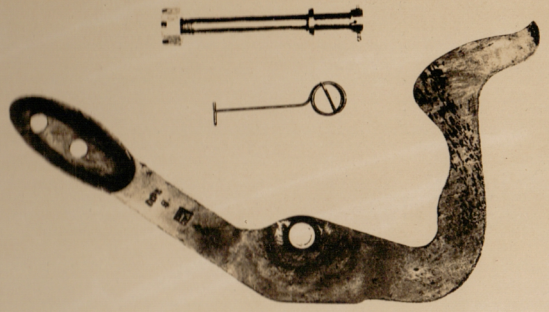
Cox's "D"



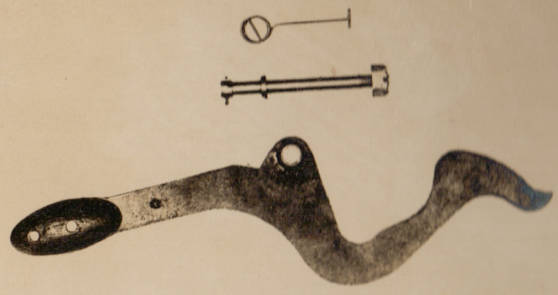
Hyland "A"



Hyland "B"



Hyland "E"



General Remarks on Synchronised Fire Control Gears.

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1. Late shots are more likely to be caused by lack of attention to the gun than by faults of the gear.

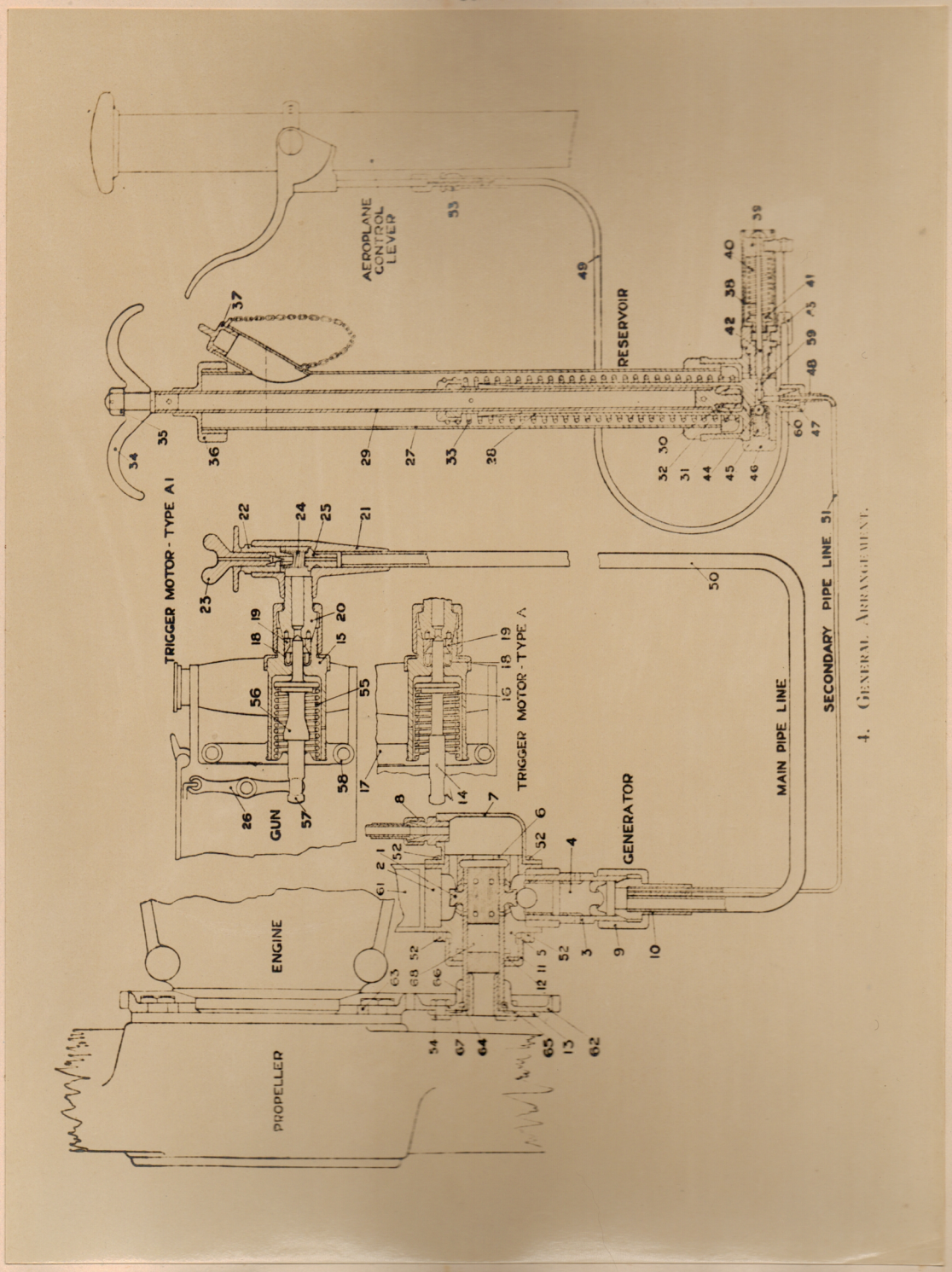
2. The chief cause of late shots is due to the cartridge caps being lightly or eccentrically hit by the firing pin ; in such cases the cap will burn slowly and so fire the charge late.

> NOTE.—At 1,200 propeller revolutions per minute 1/100th of a second delay in firing the charge will cause the shot to be fired when the propeller has passed through 72 degrees more than it should have done.

3. Any gun or ammunition fault which tends to prevent the extractor from rising quickly to its highest position may cause a late shot to be fired.

> NOTE.—Besides the usual gun and ammunition faults, the following faults may cause a late shot to be fired :—
>
> *Ammunition fault.*—Damp ammunition.
>
> *Gun fault.*—If using A. or A 1. type trigger motors with a "CC." gear see that the small lug on the trigger bar which bears against the trigger bar spring, is not bent or broken ; also, see that the trigger bar projection which rests in the fork of the trigger bar lever is not badly worn.

4. No gear must be considered fool proof, therefore, whatever type of gear is used, the Pilot must, each morning, inspect and operate certain parts of the gear (as laid down in these notes on the daily care of the gear) to ensure that it is in working order and timed correctly.



4. General Arrangement.

General Arrangement.

NOTES ON "CC." SYNCHRONISED FIRE CONTROL GEAR.

Fitting of Generator.

1. The generator usually runs at twice propeller speed, and in the case of stationary engines is usually fitted to a bracket, which is in turn bolted to the engine crank case just behind the propeller boss, and is driven by a gear wheel attached to the propeller boss running in mesh with a gear wheel attached to the generator shaft. In the case of rotary engines, the generator is sometimes driven from the main spur wheel, and in other cases the generator is done away with and a large cam ring is attached to the back of the engine, which cam ring operates a piston working in a cylinder attached to the main pipe line.

Fitting of A. and A1. Type Trigger Motors.

2. From the gun take off the firing lever, firing lever pawl, safety catch, safety catch spring with piston, and trigger bar lever; the small bridge piece holding the safety catch spring in position must be filed away. The hole through which the trigger motor plunger passes must be enlarged to be a clearance hole for it.

(a) Fit the trigger motor body and plunger without spring, and see that the banjo piece is firmly fitted and that the plunger works freely throughout the length of its stroke.

(b) Fit "CC." type trigger bar lever with the thicker prong of the fork towards the front of the gun, and see that it has a very little play in every direction; also, again see that the plunger is quite free to move through the full length of its stroke.

(c) Take the trigger bar out, hang the lock, and lay the trigger bar on the lock with its projection in the fork of the trigger bar lever; move the plunger through its full stroke, and see that the trigger bar does not lift from the lock by its projection being pinched between the prongs of the trigger bar lever when at its rearmost position. If it does lift, then open out with a file the distance between the prongs of the trigger bar lever.

(d) Shut the rear cover with the trigger bar in its guide way, but with its projection out beyond the rear cross piece; take off the trigger motor body and then push the trigger motor plunger as far forward as it will go, and while it is in this position, try to slide the trigger bar into position past the rear prong of the trigger bar lever, taking care that while so doing the plunger does not come back at all, and that the rear cover does not lift.

If the projection of the trigger bar will pass the jaw, the trigger bar lever is faulty and should be replaced.

(e) Cock the lock and place the trigger bar on the lock with its projection in the fork of the trigger bar lever. Press on the back of the trigger motor plunger and see that the trigger is tripped about a millimeter before the plunger reaches the end of its stroke. If using the A. type trigger motor, grind down the end of the spring if it is necessary to lengthen the stroke. If using the A1. type trigger motor, turn down the collar on the plunger to lengthen the stroke.

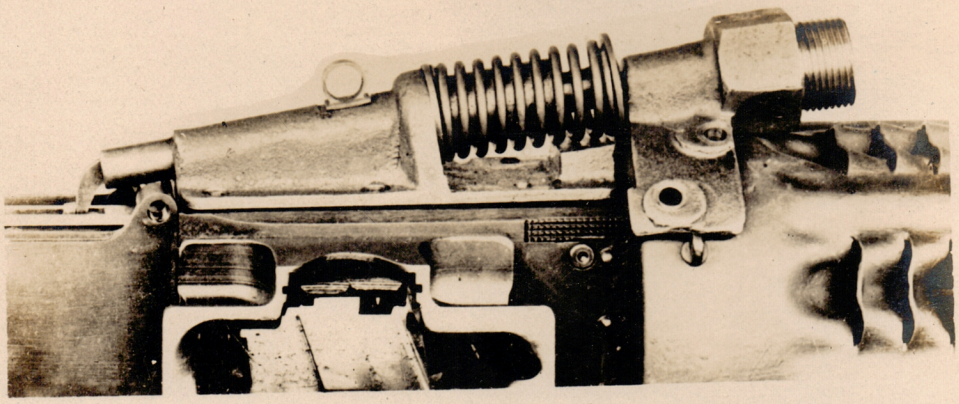
NOTE.—If using A. type trigger motor—(*i.e.*, the type with a square section spring)—it is necessary to have the spring in position while carrying out tests (c), (d) and (e).

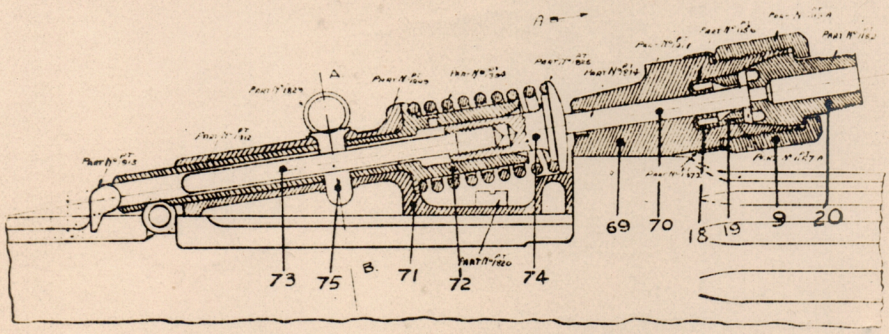
(f) Replace the trigger motor body and spring, and screw up the T piece on to the back of the trigger motor and see that the top of the trigger bar lever is drawn back during the last few turns of the union nut. If it is not, the back of the trigger motor plunger cannot be seating on the tail piece, and the cause of this should be found out and remedied.

(g) When the T piece is nipped up tight, close the rear cover of the gun with the trigger bar in its slide, but without its spring and cover lock. Insert the rear cover lock screwed pin in place of the trigger bar spring, and use it as a feeler to see that the trigger bar is drawn slightly to the rear when its projection enters the fork of the trigger bar lever. If the trigger bar is not drawn back, or will not enter the fork of the trigger bar lever, see upon which prong it catches. If it catches on the rear prong or goes straight into the fork without being slightly drawn back in so doing, the top of the trigger bar lever is too far forward. This may be remedied by turning off the necessary amount of the threaded portion of the trigger motor body.

If the projection catches the front prong of the trigger bar lever so far forward that it will not allow the rear cover to close, a metal washer must be fitted between the trigger motor body and the banjo piece. (If you are using an A. type trigger motor, the fitting of this washer alters the *fully forward* position of the plunger, and in such cases it is therefore necessary to again carry out test (e).).

(h) Take the trigger bar out of its slide and place it on the lock with its projection in the fork of the trigger bar lever and see that the trigger is at least 1 m/m clear of the end of the trigger bar slot. If there is any difficulty in getting this clearance the slot may be lengthened by filing the end of it, providing that when you did test (e) you had more than a millimeter movement of the plunger after the lock tripped ; if not, the trigger motor body must be adjusted so that it gives the best possible position for both tests (g) and (h).





"B" Type Trigger Motor.

Fitting of "B." Type Trigger Motor.

3. The gun is prepared for receiving the "B." Type Trigger Motor by removing the trigger bar and as much of the remainder of the ordinary firing mechanism as may be desired.

(a) The plunger, the trigger push rod, and the mushroom head assembled without the spring are to be tried for absolute free movement without any tendency to stick. The cause of any stiffness is to be found and removed.

(b) The trigger push rod is to be set so that it is just clear of the trigger of the gun when the mushroom head is in contact with the plunger while this is touching the tail piece.

(c) The trigger push rod is to be drawn back until the mushroom head comes in contact with its stop, and the trigger should then be one millimeter or so past its tripping position, also, while the trigger push rod is in this position, the lock should be drawn back to see that the top of the lock casing does not rub against the end of the trigger push rod. If it does, it will be necessary to either pack up the trigger push rod bracket or file the end of the trigger push rod where it touches the lock casing.

(d) The position of the trigger push rod can be adjusted either by taking out the locking clip and screwing the trigger push rod either further in or out of the mushroom head, or by opening the front cover of the gun and turning the mushroom head.

(e) To close the front cover it should be necessary to compress the spring by pressing on the mushroom head, and when closed the mushroom head should press the plunger firmly up against the tail piece.

(f) The trigger push rod and plunger should be freely oiled daily.

Fitting of Reservoir.

4. Fit so that the handle clears all controls in all possible positions of both the handle and controls, and set the reservoir as nearly vertical as possible, provided it is handy for the Pilot to reach and pull up the handle.

Fitting of Pipe Lines.

5. Lead the pipes away with as easy bends as possible and with a steady rise so that no air pockets can be formed. Clip securely wherever possible, placing rubber between the clip and pipe.

Filling.

6. The mixture of oil to consist of 90 per cent. paraffin to 10 per cent. Vacuum B.B. In extremely cold weather it may be found advisable to use P.924 oil in place of the B.B. It is important that the mixture should be well strained before use, as the least particle of grit may prevent the high pressure valve from closing.

All air must be expelled from the pipe lines in the following manner, and should be done after filling up the whole system with oil :—

(a) Pull up the reservoir handle and slacken back by about one turn the union nut at the generator.

(b) Press bowden lever, and with the other hand check the action of the reservoir handle, thereby allowing it to go down slowly as the oil is forced out of the joint at the loosened generator union; when the oil flows out from the union free of all air bubbles tighten the union nut up.

(c) Repeat actions (a) and (b) at the trigger motor union and at the air release needle valve.

(d) Fill up the reservoir again through the filler tube.

It is very important that each of the nuts and the air release needle valve should be tightened up while oil is actually flowing out, otherwise air is likely to creep into the pipe line again.

During operations (a), (b) and (c) it will be necessary to pull up the reservoir handle several times, but before doing so the bowden lever should be released each time.

The full stroke of the high pressure piston rod should be capable of giving at least 10 separate bursts of fire. If it does not, actions (a), (b), (c) and (d) must be repeated. A reservoir with good valves and high pressure piston washer should give double that number of bursts of fire if all the air is out.

Timing the Gear.

7. If using a stationary engine :—

(a) Withdraw the propeller a short distance on its shaft so that the propeller gear wheel is out of mesh with the generator gear wheel.

(b) Pull up reservoir handle and then press and release the bowden lever. The pipe lines have thus been put under pressure and the generator piston has been pushed along its cylinder into contact with the low part of the cam.

(c) Slowly turn the generator gear wheel by hand until you feel the high part of the cam coming into contact with the top of the piston, and then turn the wheel very slowly until the piston is pushed to the end of its stroke. If the wheel is turned slowly backwards and forwards about this position, the point at which the highest part of the cam is touching the piston will be readily felt.

(d) Set the propeller in the correct position relative to the axis of the gun barrel, and with the generator gear wheel still set with the high part of the cam touching the piston, force the propeller back along its shaft until its gear wheel again meshes with the teeth of the generator gear wheel.

(e) With a two bladed propeller it is usually sufficiently accurate to take the nearest tooth, but with a four bladed propeller it will be necessary to use the vernier adjustment provided between the generator gear wheel and the coupling flange, by withdrawing the three bolts and replacing them when the propeller and the high part of the cam are in the correct position.

(f) If using a rotary engine with the generator driven from the main spur wheel, the generator gear wheel should be unmeshed from the spur wheel.

(g) Turn the engine and propeller until the propeller is in the correct position relative to the axis of the gun barrel.

(h) Now perform operations as laid down in (b) and (c),

(i) Remesh the generator gear wheel with the teeth of the main spur wheel.

The position in which the propeller must be, relative to the axis of the gun barrel, at the moment the peak of the cam touches the piston, varies according to the minimum and maximum *propeller* speeds between which it is desired to fire the gun. To obtain these propeller speeds of course it is necessary to know the gear ratio between the propeller shaft and crank shaft.

(j) Check the timing in the manner laid down in paragraph 6 below.

DAILY CARE OF "CC." GEAR.

The following instructions should be followed out each day before a flight. Failure to do so will result in unsatisfactory working of the gear.

1. Fill up the reservoir through the filler tube; usually very little of the mixture, if any, will be required. An excessive amount denotes that a leakage has occurred, and the fault should be found at once.

2. Fill up the oil chamber of the Generator with Mobil-oil A. *(This is very important).*

3. Pull up the reservoir handle, and when released it should remain steady after falling a short distance.

4. Press the bowden lever. The handle of the reservoir should fall a short distance and then remain steady as if it had hit on something solid. Deal with any failure of the reservoir handle to behave as stated in (3) or (4) according to the fault table.

5. If using A. or A1. type trigger motor, see that neither the trigger bar spring nor trigger bar protection which rests in the fork of trigger bar lever are broken or unduly worn, also that the prongs of the trigger bar lever are not broken.

6. Check the timing each day by pulling up the reservoir handle, pressing the bowden lever and watching the movement of the reservoir handle while the propeller blade is moved past the point of aim. The handle should be at the top of its stroke when the propeller is in the correct position relative to the axis of the barrel.

7. Let down the reservoir handle each night (to release the tension of its spring) by repeated operation of the bowden lever. Move the propeller blade past the point of aim after each movement of the bowden lever if any difficulty is experienced in getting the reservoir handle to fall.

8. Test for fault No. 5 as laid down in the Fault Table.

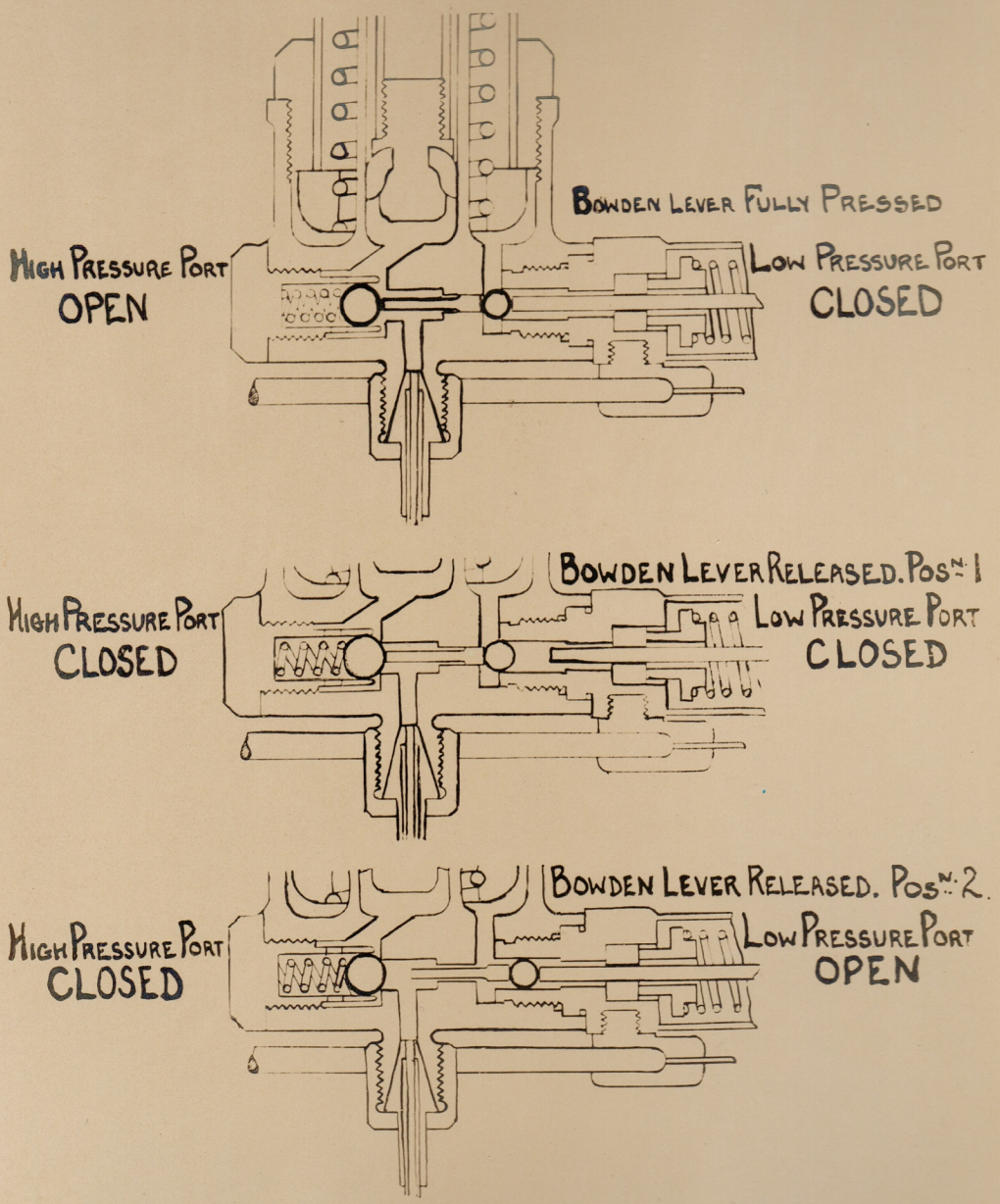
Spare Washers.

Keep spare trigger motor, generator piston and high pressure piston washers in castor oil. If, however, you are using the leather type of washer, do not keep these in castor oil, but soak them for two hours in water just before using them, and put them into position wet (thus closing the pores of the leather).

"CC" GEAR FAULT TABLE.

Failure in the Gear is always shown by the behaviour of the reservoir handle and can be easily located.

Notification.	Action.	Fault.	Repairs.
1. After pulling reservoir handle to the top of its stroke it sinks at once to the bottom without operation of the bowden lever.	Unscrew filler cap, fill up reservoir, and expel all air from the system.	Not enough liquid in the reservoir.	
2. After pulling reservoir handle to the top of its stroke it sinks slowly without operation of the bowden lever.	Press bowden lever fully home. Reservoir handle will drop quickly about half an inch. If handle then stops falling,	High pressure valve leaking due to :—	
		Grit under ball valve or	Clean valve seating.
		Damaged valve seating	Tap the steel ball with a copper drift to bed it on to the seating.
	If with bowden lever fully pressed the handle does not stop falling, but continues to fall at the same rate as before,	Damaged high pressure cup packing.	Fit new high pressure cup packing.
	If handle falls quicker than before,	Leak in the pipe lines in addition to high pressure valve leaking.	Go round all unions and screw them up tight. If a leak is found in the copper pipe lines or at the joints, change the pipe line.

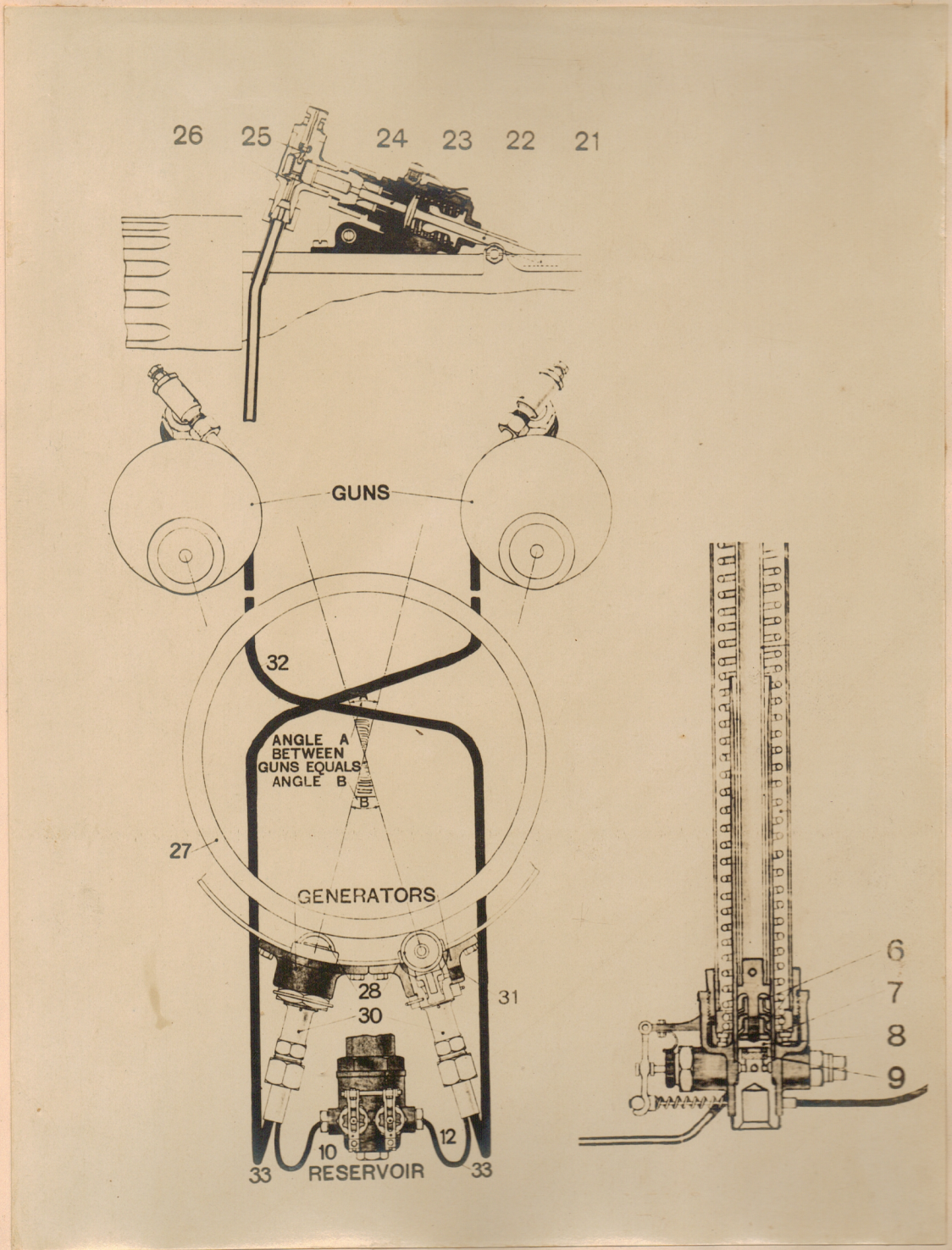

BOWDEN LEVER FULLY PRESSED
HIGH PRESSURE PORT
OPEN
LOW PRESSURE PORT
CLOSED
BOWDEN LEVER RELEASED. POSN. 1
HIGH PRESSURE PORT
CLOSED
LOW PRESSURE PORT
CLOSED
BOWDEN LEVER RELEASED. POSN. 2.
HIGH PRESSURE PORT
CLOSED
LOW PRESSURE PORT
OPEN

Notification.	Action.	Fault.	Repairs.
3. After pulling reservoir handle to the top of its stroke it remains steady, but on pressing bowden lever it sinks slowly to the bottom.	Pull up reservoir handle to the top and fill up reservoir until oil is level with the top of the filler tube. Press the bowden lever fully home. If oil now overflows at the filler tube	Low pressure port leaking, due to either a worn or damaged valve seating or grit.	If the seating is badly worn or damaged make a new seating with the re-seating tool; if not, then gently tap the taper pin into the low pressure port, and then place the ball in position and tap it on to its seating with a copper drift.
	If oil does not overflow	Leak in the pipe lines or at the unions.	
4. When bowden lever is pressed the handle of the reservoir drops too far and does not quickly come to a definite stop.	Unscrew for a few turns the air release needle valve. Hold reservoir handle, press bowden lever and let handle of reservoir down slowly until the oil flows through the needle valve free of any air bubbles.	Air in the system.	
5. While pressing the bowden lever with the engine running, the trigger motor plunger operates, but only through a short stroke, and does not trip the lock (during this test the engine should be running at over half full speed, and the gun must be unloaded).	Cock the lock. Press hard on the reservoir handle. If the lock trips	Weak reservoir spring.	Fit a new reservoir spring.
	If the lock does not trip	Trigger motor spring too strong.	Cut off half a coil of the trigger motor spring.

Re Action for Notification (4).

Be careful to close air release needle valve while liquid is still being forced through. If any difficulty is experienced in expelling all air from the system, run the engine with all unions and air release needle valve tightened up, pull up the reservoir handle and operate and release the bowden lever about thirty times, pulling up the reservoir handle every time it reaches the end of its stroke; then stop the engine and repeat the action as given for (4).

NOTE.—If after standing overnight the reservoir is found to have emptied itself, the leak is probably in the union of the small bore pipe to reservoir, or at the leather through which the control needle passes. If the latter, the leather must be replaced.



"C" Type Trigger Motor, Generators and Reservoir.

Notes on Sopwith Kauper Synchronised Fire Control Gear.

1. Always make certain that the gun is unloaded before touching the bowden control, or any other part of the gear, or gun to which it is attached, as, if a round has been left in the chamber, it may be fired by the least movement of any part of the gear.

2. When closing the rear cover of the gun always have the lock drawn back about an inch, as otherwise the Trigger Finger is likely to foul the top of the trigger as the cover is closed. (See also paragraph 19.)

Adjustment of the Gear.

3. The main-spring should be assembled on the front and rear-spring anchorages, so that when the feathered guide rod is in the non-firing position, there is about a quarter of a turn of torsion on the spring tending to keep the side of the guide rod feathers firmly against the stops on the front-spring anchorage. The feathered guide rod should then be put in position in the end pillar, and the front-spring anchorage pinned to the three-pin lever.

The end lever should then be securely fixed into position so that its projections are in the grooves provided for them when the rear-spring anchorage is very slightly rotated against the torsion of the spring. This makes it certain that the feathers coming hard up against their stops will not prevent the projections registering correctly with the grooves in the pillar. The fit of that part of the feathered guide rod which runs through the end pillar should be such that the light spring is able to draw it freely forward.

4. The bowden lever should then be pressed sufficiently to just draw the projections of the end lever out of the grooves in the end pillar, but not far enough to bring the feathers opposite the slot in the front-spring anchorage. The engine should be turned so that the highest part of the cam passes backwards and forwards under the tappet roller. The front-spring anchorage should have an appreciable movement each time the engine is so moved.

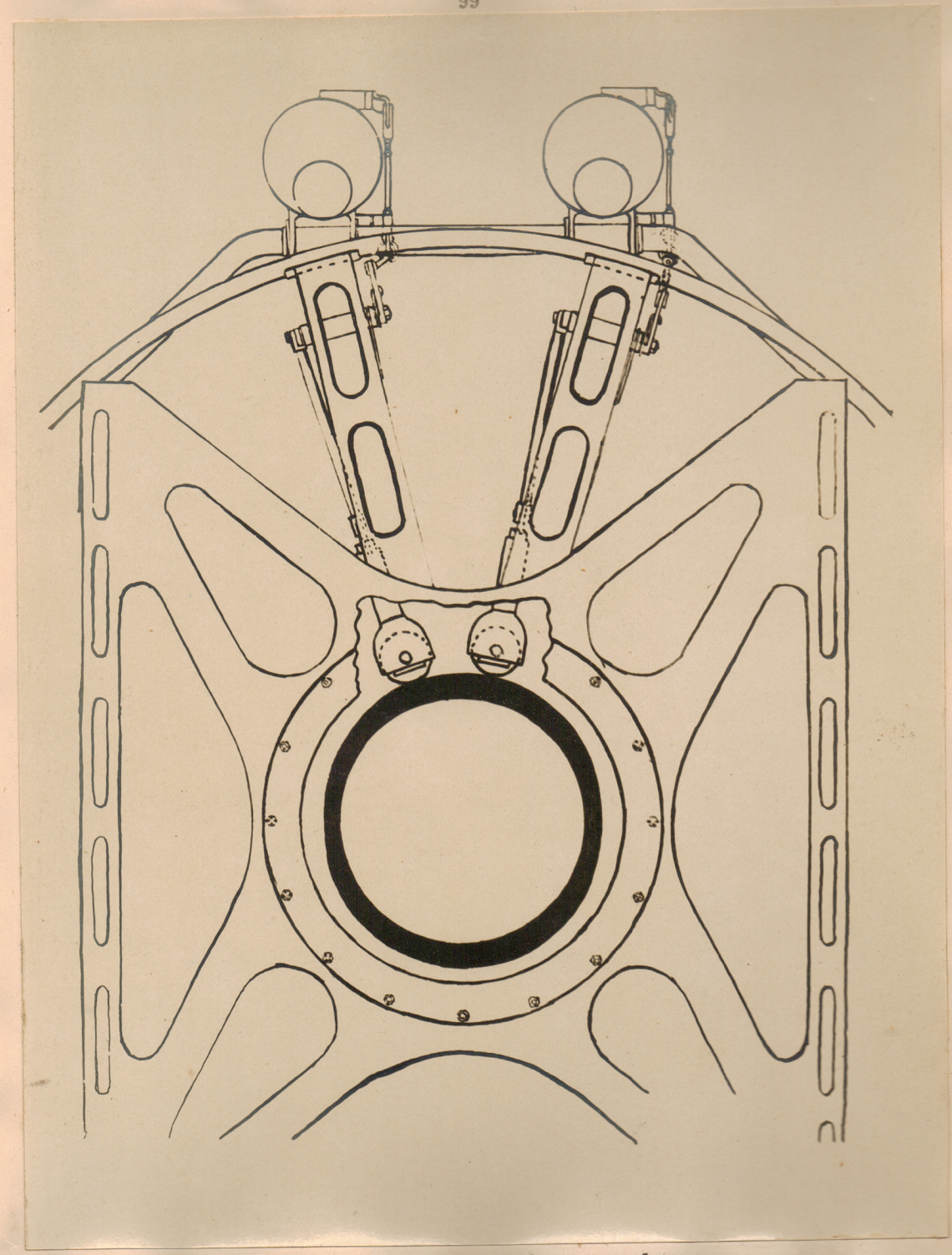
Such movement is essential to make certain that no matter in what position the feathers may be at the moment the bowden lever is released, the slot in the front-spring anchorage will be drawn clear of the feathers the next time either peak of the cam passes under the tappet; and thus leave the feathers free to rotate until they engage against the stops on the front-spring anchorage, and so prevent any further action of the gear.

5. This condition of the gear is obtained by :—

(a) Loosen the lock nuts of the long pull rod and give it two or three turns in the direction which will lengthen it.

(b) Press the bowden lever and turn the engine until one of the peaks of the cam is immediately under the tappet roller, then release the bowden lever.

NOTE.—As the cam cannot be seen (due to it being covered by the rear drum cover plate) its position relative to the tappet must be found by watching the movement of the long pull rod, while the engine is turned, with the bowden lever pressed.



View of Gear with engine removed.

(c) If on releasing the bowden lever the end lever returns to the "Off" position, it will be necessary to still further lengthen the long pull rod, until the end lever does not return when you release pressure on the bowden lever.

(d) Shorten the long pull rod slowly until the end lever just returns to the "off" position, and then continue to shorten it by half a turn beyond the point where it just allowed the end lever to return. Now tighten up the lock nuts.

(e) Test the accuracy of your adjustment by turning the engine a quarter of a revolution, press the bowden lever and release it again, and then turn the engine a further quarter of a turn, so again passing the peak of the cam under the tappet roller, and see if this last movement of the engine allows the end lever to return to the "off" position. If it does not, then you must still further shorten the long pull rod.

Repeat this test for the other peak of the cam.

6. The short pull rod should now be adjusted so that when the engine is turned slowly the trigger is only just tripped when the lowest part of the cam is under the tappet roller.

This adjustment is obtained in the following manner, and should be set very fine, as otherwise it is possible for the gun to fire either early or late shots :—

(a) Turn the engine (with the bowden lever pressed) until either depression of the cam is immediately under the tappet roller.

(b) Release the bowden lever and lengthen the short pull rod until you find that if you pull the lock back and then let it go forward again it does not trip.

(c) Shorten the short pull rod slowly until the lock just trips. Shorten it still further by one quarter of a turn and carefully tighten up the lock nuts.

(d) Test the accuracy of your adjustment as follows :—

(e) Turn the engine quarter of a revolution and then cock the lock.

(f) Press the bowden lever and keep it pressed while someone else turns the engine until the lock trips.

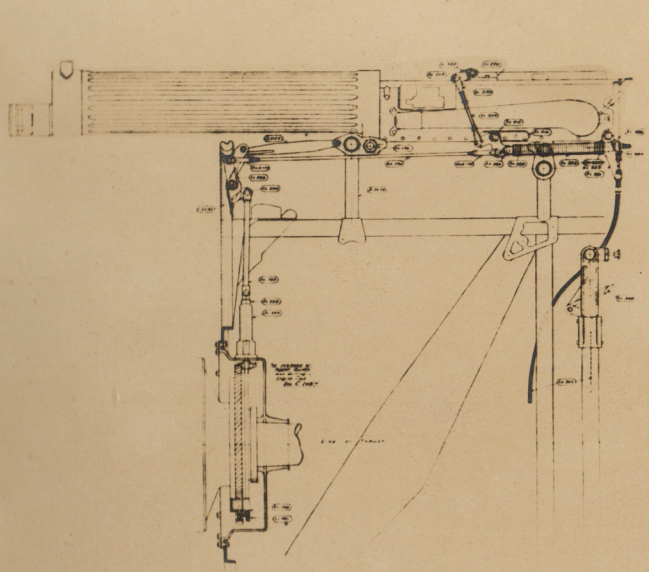
NOTE.—If the bowden lever is pressed too hard it prevents the full downward movement of the short pull rod, due to the excessive friction set up between the sides of the feathers and the sides of the slot in the front-spring anchorage.

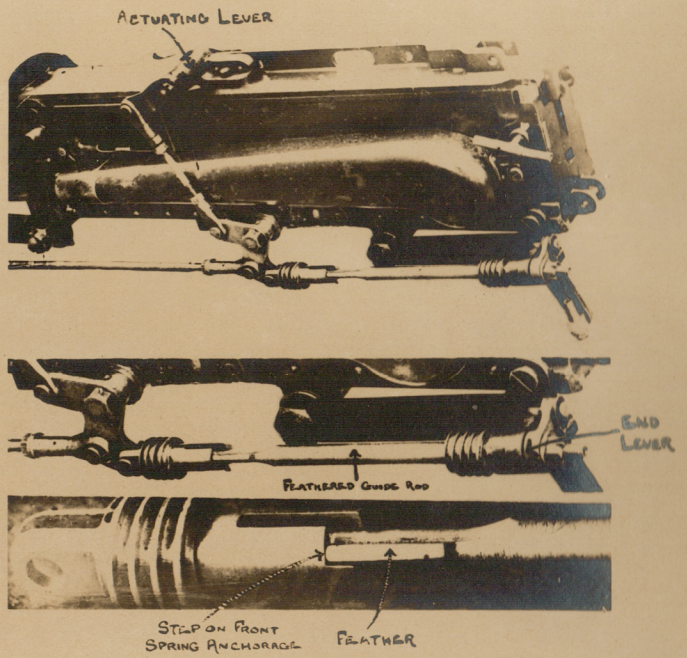
(g) If immediately after the lock trips the short pull rod continues its downward movement for an appreciable distance as the engine is turned a little further round, then your adjustment is too coarse, and should be made finer by slightly lengthening the short pull rod.

If, however the lock does not trip as the cam depression passes under the tappet roller, then your adjustment is too fine, and should be corrected by shortening the short pull rod.

(h) Repeat (d), (e), (f) and (g) for the other cam depression. If it is found that the lock trips at slightly different points at each half revolution of the engine, it may be due to the cam being eccentrically mounted on the distributor of the engine. If it is considerably out the cam must be centred correctly.

7. Both gears must be adjusted independently when two guns are fitted.





General Arrangement.

Each of the above three views shows the Bowden Lever released.

1. **Note position of Actuating Lever.**
2. **Note position of End Lever and Feathered Guide Rod.**
3. **Note position of Feathers relative to the step of Front Spring Anchorage.**

Timing.

8. The propeller should be put on the shaft in such a position that its trailing edge is six inches past the line of fire at the moment the lock trips. If this position cannot be obtained by altering the position of the propeller on the eight bolts which hold it to the shaft, the engine nose-piece must be taken off and put on again one or two bolt holes further round, according to the amount of adjustment required.

By making use of the Vernier adjustment provided by means of the eight holes in the propeller boss and the fourteen bolt holes in the engine nose piece, an adjustment to within seven degrees can be obtained.

9. Check the accuracy of your timing by tripping the lock when the propeller is turned both forward and backward. If the timing is correct, the position of the propeller will be very nearly the same at the moment the lock trips, whichever way you turn the propeller.

10. Having set the timing for one gun, it should be correct for the other gun also; but this should be checked by cocking the lock of the second gun, pressing the bowden control, and turning the propeller slowly past the muzzle. If its lock trips when its trailing edge is approximately in the same position relative to the axis of the barrel of the second gun, as it was for the first gun, the timing is correct for that gun also.

If it does not (and assuming that the long and short pull rods are adjusted correctly) the tappet guides are not mounted on the rear drum cover plate in the correct place; this fault is very unlikely to occur.

11. Remember not to keep the bowden lever pressed too hard while doing any test which involves the lock being tripped, as by pressing too hard it is possible to prevent the lock being tripped for the reason given in the "Note" at the bottom of para. 6 (f).

Maintenance.

12. All lock nuts and bolts must be kept tight, and all pins securely split-pinned.

13. All joints and the tappet and roller should be freely lubricated.

14. The timing should be checked after each landing by cocking the locks of the guns and turning the propeller slowly with the bowden levers pressed, and noticing the position of the propeller when the locks trip.

15. Any wear at the joints of the gear between the tappet roller and the three-pin lever will tend to make the lock trip earlier, and should be adjusted for as necessary by shortening the long pull rod.

16. Adjustment will be necessary until the gear has run in, but should not be required so frequently afterwards if all the joints, etc., are kept carefully lubricated.

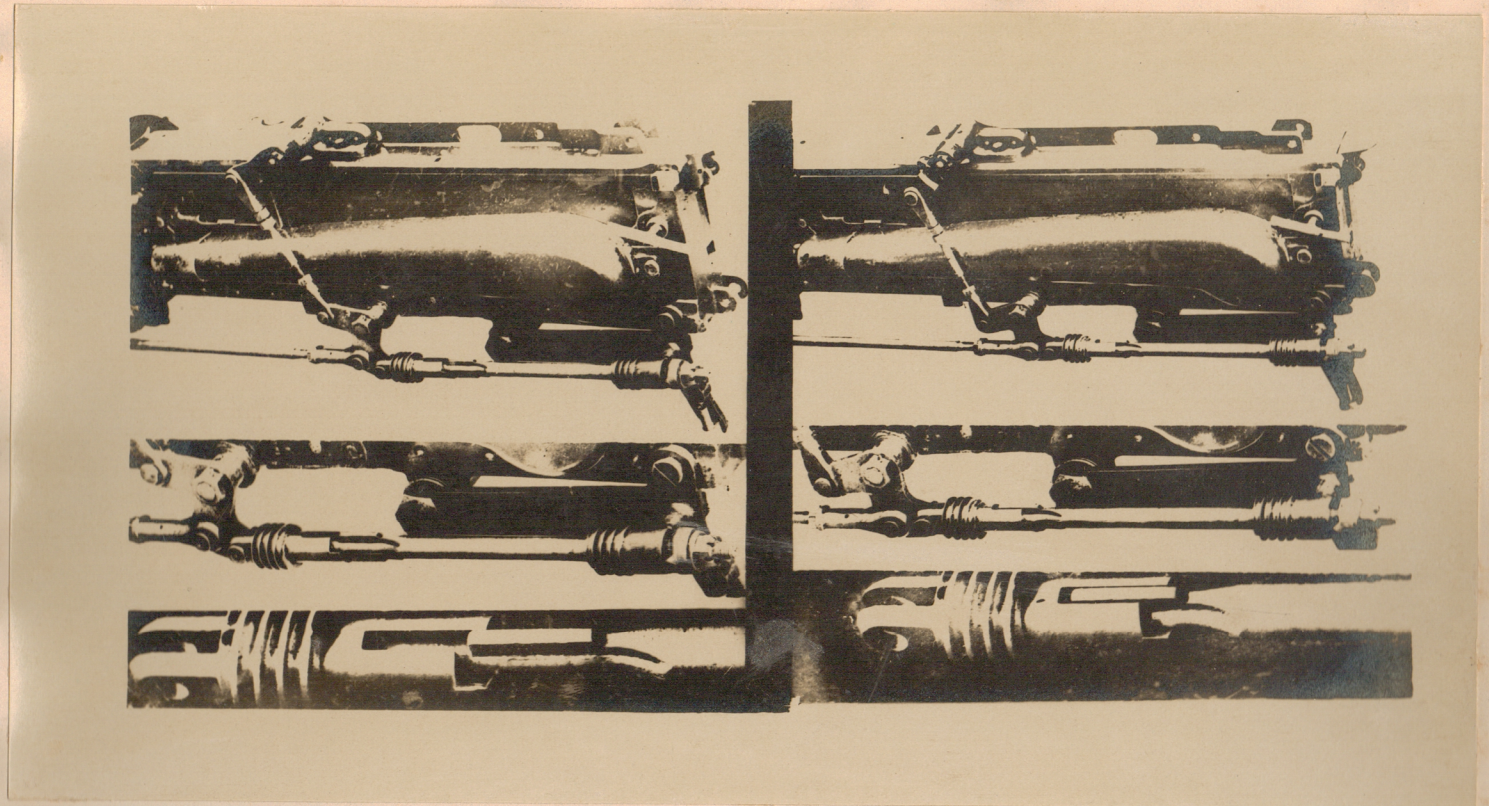
17. The putting of the gear in and out of action should be frequently checked and adjusted as necessary by means of the long pull rod and the torsion of the main spring. Too much torsion will make the bowden control stiff, and too little will make the stopping of fire uncertain.

18. The adjustment of the gear should always be checked particularly carefully after the machine has made a bad landing, as any undue strain on the fuselage will considerably upset the adjustment of the gear.

19. Care must be taken that the short pull rod, etc., take up their correct positions when the rear cover of the gun is closed. No force is necessary to shut the cover, and none must be used.

Caution.

Always unload the gun before leaving the machine.



Each of the above three views shows the Bowden Lever pressed when a peak of the cam is under the tappet.

1. Note the position of the Actuating Lever.
2. Note the position of the End Lever and Feathered Guide Rod.
3. Note the position of the Feather relative to the slot in the Front Spring Anchorage.

Each of the above three views shows the Bowden Lever pressed when a depression of the cam is under the tappet.

1. Note the position of the Actuating Lever (when in this position the lock is just tripped).
2. Note the position of End Lever and Feathered Guide Rod.
3. Note the position of the Feather relative to the slot in the Front Spring Anchorage.

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